THE ENGINEER.

Milling Machines.

MILLING MACHINES.

MILLING machines in their present state of evolution may be divided broadly into two classes:—(1) Machines for special purposes, and (2) machines of general utility. The first class naturally contains a great number of types of machines which have been evolved to satisfy the special demands of different industries, and range from small bench machines designed for very light work—such, for example, as grooving sewing machine needles—up to the heaviest class of machines, often with a number of spindles each placed so as to take its own particular cut in its own particular place, and having no provision for general adaptation to a variety of work. Machines of such special types are doubtless of the greatest interest to those engaged in the industries which employ them, and also, perhaps, to those who make them; but as detailed information regarding them is difficult to obtain, and as their variety is far too great for them to be adequately covered even by a special supplement to this journal, it is deemed best to give the greatest consideration to machines of the second class, namely, of types that can be employed by the majority of engineers and manufacturers who have metal cutting to do. General utility machines in themselves exhibit much variation in design and type. We have, for instance, horizontal and vertical spindle machines, either of which may be be of column or planing-machine type. Horizontal spindle machines may be either plain or universal, and the columns of plain machines may be either fixed or travelling along a bedplate, as in the case of the large machines known as boring and milling machines. The work may be fixed and the spindle adjustable, or *vice versâ*; this in either vertical or horizontal planes. Vertical milling machines may also be of very varying type; either the column machine or the planer type of machine may be adapted for plain milling or for copying, and either type may or may not be suitable for circular milling; the spindles may be arranged to swivel, and vertical and horizontal spindles may even be combined in the same machine. These considerations render it difficult to generalise on anything but on those points which are essential to milling machines of all types.

In considering the various features of general utility machines, it should be fully realised that they can be advantageously used also for producing repetition work, and even work of a very unusual character for milling machines if they are fitted up with suitable attachments, tools, and fixtures. Some of the leading manufacturers prefer to utilise standard types of machines for special repetition work, even if expensive outfits are required with them, on account of the possibility of utilising them on other work if trade conditions change, and also on account of the facility with which such machines can be obtained through ordinary trade sources.

The essentials of a good general purpose milling machine may be briefly indicated under the following heads:—

1. The cutter; its material and design.
2. The arbor; its material and strength.
3. The spindle; its proportions and design.
4. The arbor support; its convenience and efficiency.
5. The spindle bearings; their dimensions, their design, and their means of adjustment.
6. Power available at the spindle.
7. Speed range.
8. The strength and weight of the machine as a whole.
9. The work table; its strength, adjustment and support.
10. The feeds; their range and convenience.
11. The general handiness of the machine.
12. The accuracy of the machine, and the means for fine adjustment.

First-class workmanship is necessary for all machinery according to the requirements of its class, but should be specially emphasised in the case of the milling machine, on account of the large stresses which are dealt with, and the high character of the product which is usually required. It is not intended in these introductory notes to enlarge unduly on the various headings given above, as their mere enumeration will probably tend to induce in the mind of the reader the proper mental attitude necessary for intelligent and impartial appreciation of the features of the machines illustrated. We have, however, permitted ourselves to discuss briefly some of the more important points, such as the relation between speeds, the possibilities of the milling cutter, and the influence of high-speed steels on milling.

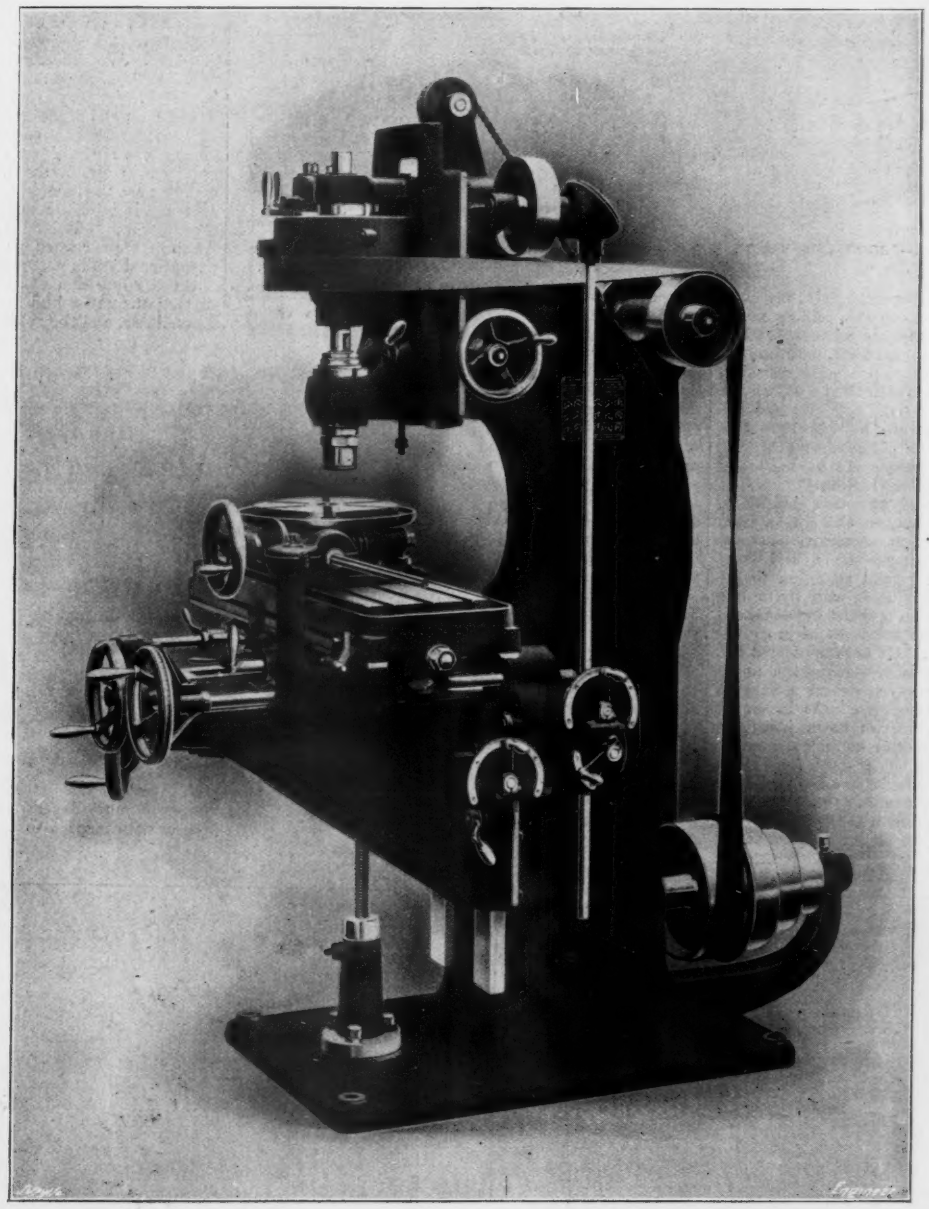


Fig. 1—VERTICAL MILLING MACHINE—J. ARCHDALE & CO., LTD.

The milling cutter in its original form was obviously derived from the file; the earliest cutters resembled files in the character of their surface, and acted as files in practice. Such cutters were used by some of the French clockmakers of the eighteenth century to do the work generally performed at that time by hand files. One of these cutters, attributed to Vaucanson, is now in the collection of Mr. Lucien Sharpe, of Providence, U.S.A., and is a formed cutter similar in shape to the modern gear cutter but with very fine teeth. Such a tool could not be sharpened except by first softening it, and it had only a very limited capacity for utilising power and for removing metal.

Probably on account of the limitations of the cutters which were available, and because of the lack of appreciation of its high possibilities, the milling machine developed very slowly until the invention of the cutter grinder — about 1877 — which enabled the efficiency of the cutting tools to be easily maintained, and greatly encouraged their use; but in contrast with this fact it is worth while noting that the universal milling machine, with all its really essential features, was patented in America as early as 1865 by J. R. Brown, of the firm of J. R. Brown and Sharpe, of Providence, and in its leading principles remains unchanged to this day. Until the invention of the cutter grinding machine, the milling cutter was looked upon as a tool of precision, and one only to be used for delicate or difficult work, and it may easily be imagined that milling cutters were treated very tenderly, and that such cuts as are now taken in ordinary practice would have been looked upon with horror rather than with respect. The first cutter grinder we are able to trace was designed and patented in 1877 by a French engineer, Kreutzberger, who received his training in various factories in the United States, notably in the Remington Small Arms Factory, where he was works manager. The invention of the spiral milling cutter has been attributed to a Swiss engineer named Vetterli, who is said to have invented this type of cutter whilst in charge of a small arms factory not far from London Bridge. Some of these claims have been disputed, and are therefore given here without authority. It is sufficient for modern users to be thankful that the improvements have been made, and have enabled great progress to be achieved in the mechanical arts.

Since the invention of the cutter grinding machine, the improvement of the milling machine has been steadily proceeding, until it now occupies a leading posi-

tion among labour-saving machine tools; but the development of the last few years, although great, has perhaps been more in the direction of obtaining greater output from machines of known type than in the direction of introducing any epoch-making novelties in milling machines. It has begun to be appreciated that even under the best of conditions the tooth of a milling cutter only takes a very small bite compared with that taken by the cutting edges of other machine tools, and that the cutter is still ahead of the machine in producing capacity. There appears to be no reason, save that of cost, why in the near future the machine should not overtake the cutter, but sufficient has been shown by recent progress in the use of milling cutters to indicate that milling machines of greater weight and power will be built, and will justify their cost in increased production.

It has been asserted that special attention directed to methods in the machine shop has, on the whole, been productive of at least as much economy as have improved appliances and high-speed steels, and there appears to be little doubt that special attention to the tools and methods adopted for producing work by milling offers at the present day as good an opening for enhanced results as the adoption of the latest classes of machines or the use of high-speed cutters. An argument that has been used to defend the engine lathe against the turret lathe is that the turret lathe receives expert assistance from the tool designer which the engine lathe lacks, the reason being that the turret lathe can never justify its cost unless it is properly tooled and equipped, whereas the simpler engine lathe will produce some kind of an output without any special equipment at all. The same argument can be applied to the milling machine contrasted with the planing or shaping machine, and it is a fact that the milling machine, just as much as the turret lathe, requires to be properly equipped and properly maintained if it is fully to justify its existence. The advantages of the milling machine over the shaper or planer are, perhaps, greatest in cases where difficult work needs to be done requiring some expert skill in planning, and the provision of suitable cutters, fixtures, and appliances; but it is nevertheless a fact that the limits of the milling machine as a metal-removing tool pure and simple have never yet been reached in practice.

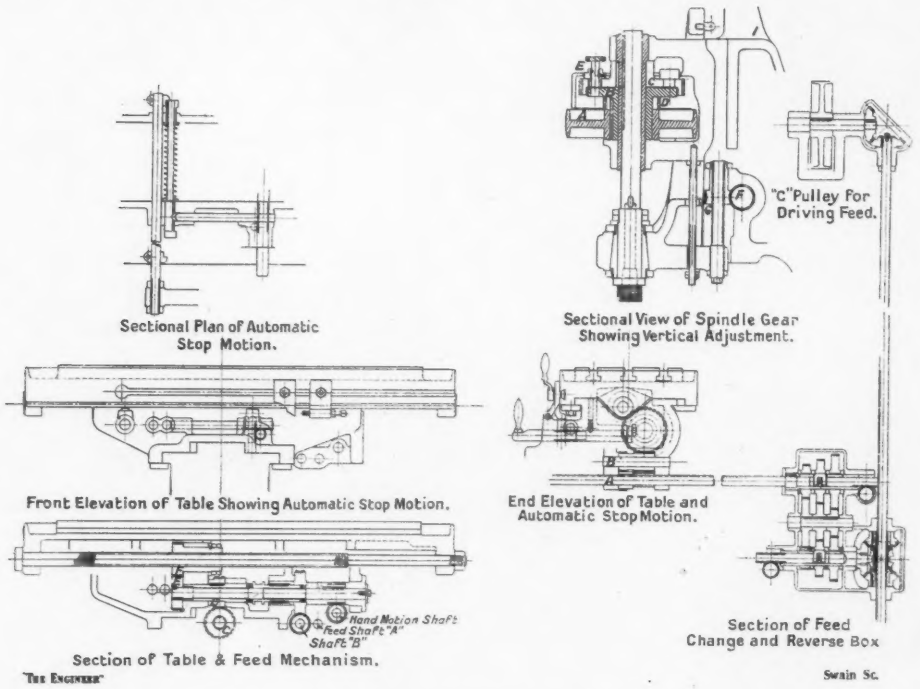

Sectional Plan of Automatic Stop Motion.
Front Elevation of Table Showing Automatic Stop Motion.
Hand Motion Shaft
Feed Shaft "A"
Shaft "B"
Section of Table & Feed Mechanism.
"The Engineer"
"C" Pulley for Driving Feed.
Sectional View of Spindle Gear Showing Vertical Adjustment.
End Elevation of Table and Automatic Stop Motion.
Section of Feed Change and Reverse Box
Swain Sc.

Fig. 2—ARCHDALE'S VERTICAL MILLING MACHINE—DETAILS

A prominent feature in the design of all general utility milling machines is the provision of two speed varying devices, one for adjusting the speed of the cutter spindle, and the other for regulating the feed, and it is largely on the subject of these devices that rival makers urge their claims. It does not lie within the province of these notes to advocate any particular make or type of machine, and each user may hold his own opinion on the merits of the arrangements provided for driving and feeding, but there can hardly be two opinions on the following points:—

(*a*) The quickest spindle speed should be fast enough for the smallest cutter in regular use.

(*b*) The slowest spindle speed should be slow enough for the largest cutter.

(*c*) Every diameter of cutter in ordinary use should have a range of feeds sufficient to enable it to do really efficient milling, according to its class.

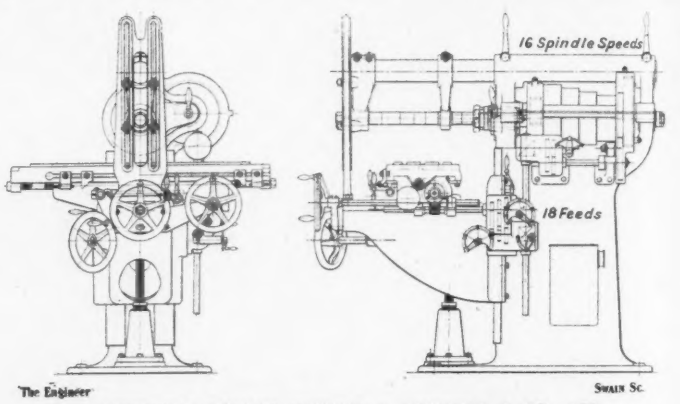


Fig. 3—HORIZONTAL MILLING MACHINE—J. ARCHDALE & CO., LTD.

should be in geometrical progression. The only justification for restricted ranges of feeds or speeds is that either the work to be done, or the sizes of the cutters to be used, are restricted; in other words, that the machine is not to be used as a general utility, but rather as a special purpose machine. As soon as the special purpose idea becomes paramount both speed and feed range can be cut down, in some cases to one speed and one feed only, without losing any advantages and with a beneficial reduction in complication and cost, but it must not be expected that the resulting machine will deal efficiently with a great variety of work or with cutters of greatly varying size. If it be admitted, then, that the general utility milling machine should have a wide speed range and a wide feed range, it follows that both should be available at all times—that is to say, that it should be possible to use any feed with any speed. The rate at which the spindle should run depends upon the diameter of the cutter, other things being equal, but the rate of feed is independent of the diameter, as such, of the cutter and dependent on the character of the cut to be taken and on the strength of the cutter and of the work. Assuming a milling machine to have feeds varying from, say, ¼in. up to 12in. per minute, there is no doubt that work can be done with cutters varying greatly in diameter at all feeds within the limits of this range; hence the conclusion that the feeds should receive their motion from the same common constant speed source as the spindle, and that each of the two speed-varying devices, viz., for speed and feed, should be independent of each other and independently variable.

Progress in milling has been so great during recent years that, in view of probable further advances, it is difficult to state definitely what ranges of feed should be provided. We know that milling can be done at feeds up to about 30in. per minute, or even more, but it is very doubtful if the proportion of work which can be fed faster than 12in. per minute is enough to warrant the provision of higher rates on machines for everyday work. The greater the range of feeds the greater is the complication required to obtain them, and in many cases the more complex are the operations of making the changes, and although it is desirable to have enough feeds, it is commercially unprofitable to extend the range beyond the limits of regular work for the sake of doing an occasional exceptional job in a showy manner.

On the question of the relative power consumed in driving the cutter and in feeding, very little information is available, and the subject presents an interesting field for investigation. It would appear that the feed power required must depend on the direction of the milling cutter with respect to the feed travel; for example, we should expect more power to be required to feed the work under a cylindrical cutter rotating in a direction opposed to the feed than under a face cutter, the motion of which has a large component at right angles to the feed. Be

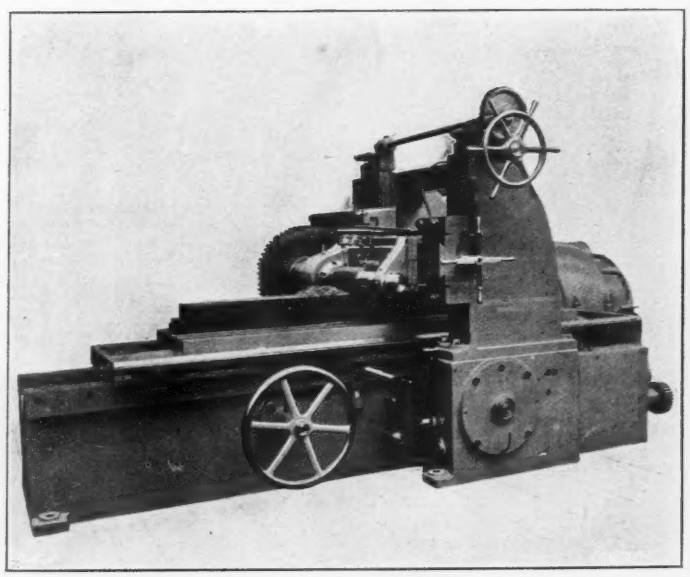


Fig. 4—SLAB MILLING MACHINE—ARMSTRONG-WHITWORTH

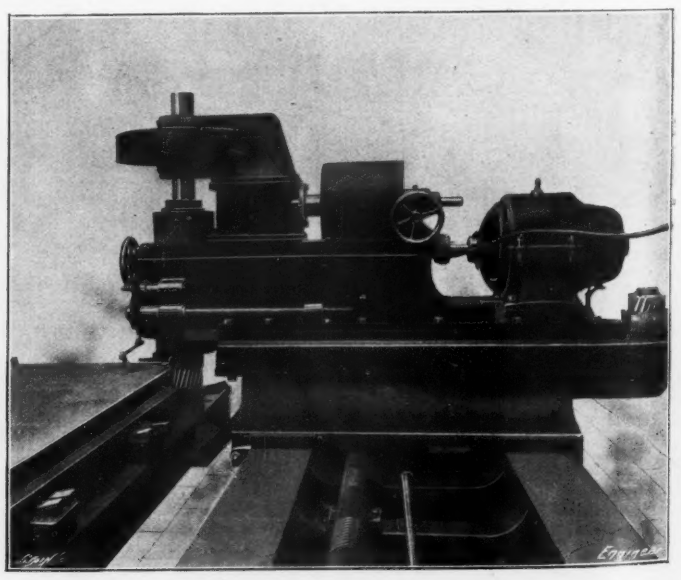


Fig. 5—PLATE-EDGE MILLING MACHINE—ARMSTRONG-WHITWORTH

As the diameters of cutters and the depths and widths of cut may be anything between the maximum and the minimum provided for, the spindle speeds and the feed rates should advance in regular order; in other words,

this as it may, we are informed that in some experiments recently made by a leading firm on a vertical milling machine using a face cutter milling cast iron, the power of the feed belt was such as to be capable of transmitting 50 per cent. of the power supplied to the machine, that is to say the horse-power of the spindle drive and of the feed were equal, and yet the feed belt was the first to slip, thus pointing to the fact that the power required for feeding may be much greater than is generally realised.

It is doubtful if any milling machines are now offered which are not said to be suitable for using high-speed steel cutters, and it may be worth while inquiring what has been the effect of the introduction of high-speed steel on the design of the milling machine. In general terms it may be said that high-speed steel has been responsible for very few changes in design. It has enabled existing machines to be speeded up, and this has caused greater attention to be paid to the manufacture of the gearing to secure quiet running. It has necessitated quicker feeds in order to get some benefit from the greater speeds of rotation, but in other respects its direct influence has been negligible. The general stimulus, however, which was given to the machine tool industry all round by the discovery of high-speed steel has doubtless had a much greater effect in improving the mechanical details of milling machines, and in favouring the development of milling as a workshop process than the mere properties of the steel itself, and users of milling, as of other machine tools, are now much more anxious that their machinery shall produce its utmost output than was the case prior to the year 1900. We have thus to thank the discoverers of high-speed steel for many indirect benefits as well as for the more obvious results of their discoveries.

The design of the cutter itself has been shown in recent years to be capable of no small improvement, and the adoption of coarse teeth with the accompanying short spirals has greatly increased the maximum production of the cutter. For a long time cutters were made, and we are afraid are still often made, as if their output were about in proportion to the number of teeth in them, and it was not realised that no single tooth ever approached its maximum cut, or that the metal-removing properties of a given cutter could be increased by taking away every alternate tooth so as to enable the remaining teeth to take a proper cut and to avoid heating them up and grinding them away against the surface of the work by not giving them enough to do. Leaving for a moment

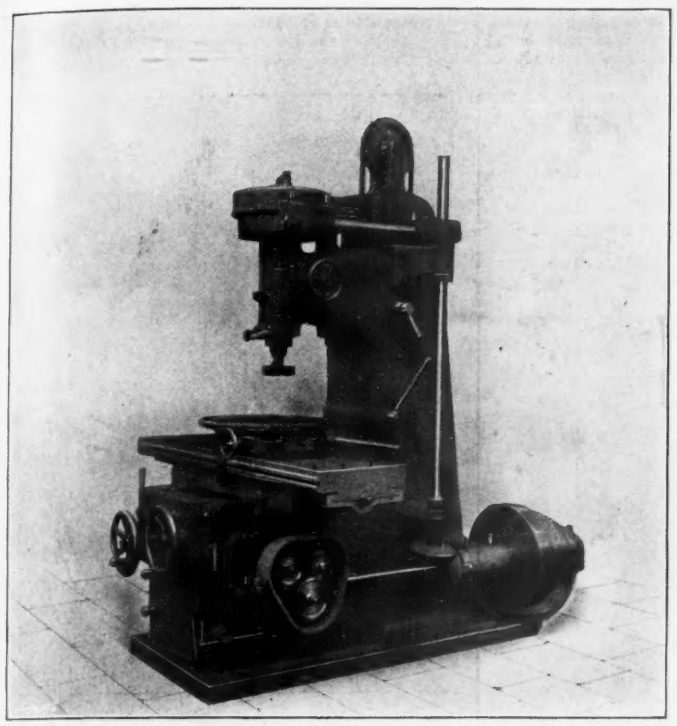


Fig. 6—VERTICAL MILLING MACHINE—ARMSTRONG-WHITWORTH

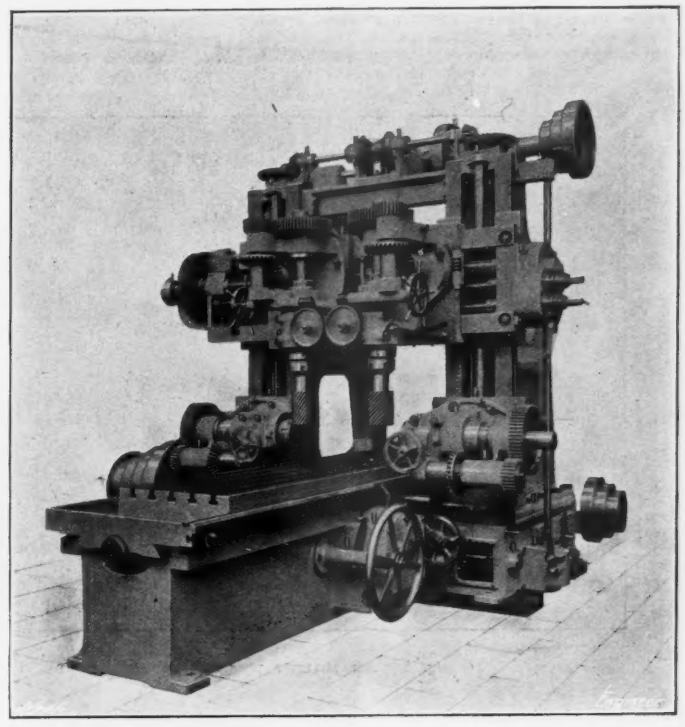


Fig. 7—FOUR-SPINDLE MILLING MACHINE—ARMSTRONG-WHITWORTH

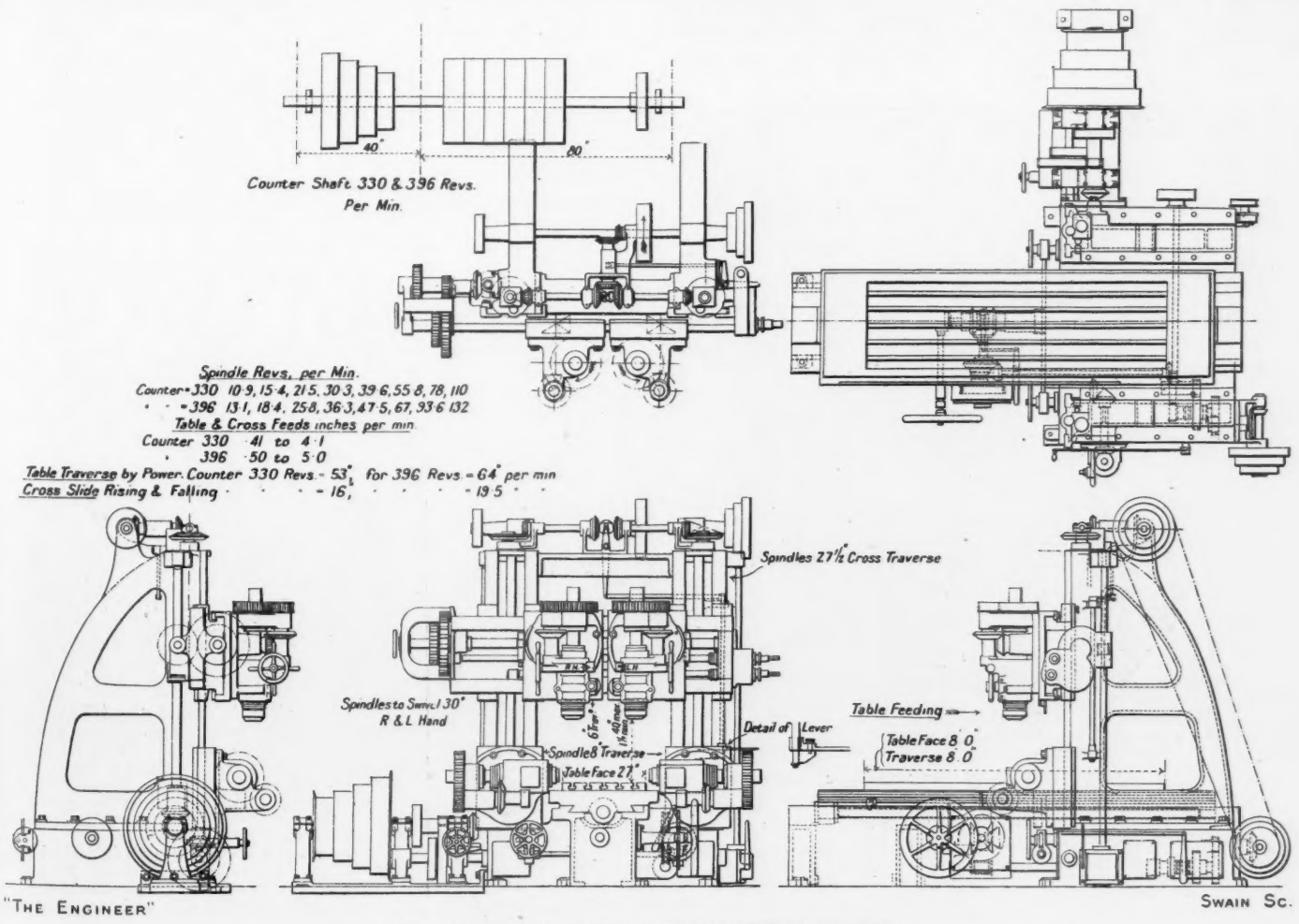

40"
80"
Counter Shaft 330 & 396 Revs. Per Min.
Spindle Revs. per Min.
Counter 330 10·9, 15·4, 21·5, 30·3, 39·6, 55·8, 78, 110
" 396 13·1, 18·4, 25·8, 36·3, 47·5, 67, 93·6 132
Table & Cross Feeds inches per min
Counter 330 ·41 to 4·1
" 396 ·50 to 5·0
Table Traverse by Power. Counter 330 Revs. = 53" for 396 Revs. = 64" per min
Cross Slide Rising & Falling " = 16" " " = 19·5 "
Spindles 27½" Cross Traverse
Spindles to Swivel 30" R & L Hand
Spindle Traverse
Table Face 27"
Detail of Lever
Table Feeding
Table Face 8' 0"
Traverse 8' 0"
"THE ENGINEER"
SWAIN SC.

Fig. 8—FOUR-SPINDLE MILLING MACHINE—ARMSTRONG-WHITWORTH

the question of the mere weight of chips produced, it may be observed that the invention of the relieving lathe enabled difficult forms to be machined cheaply by simplifying the process of making and maintaining, and by lengthening the life of formed cutters, thus greatly encouraging the adoption of milling for many classes of work previously produced by other methods. Lastly, our improved knowledge of tool steels of all kinds and the substitution of precise and scientific methods of hardening and tempering for the semi-occult practices formerly obtaining among tool-hardeners has enabled good and uniform cutters to be produced, and has removed many of the risks previously attendant on the use of milling cutters.

With these few words of introduction, we shall now proceed to describe a number of milling machines which represent the latest developments in this direction. It will be observed, however, that only tools of British origin are dealt with. This, we need not say, is not due to any lack of appreciation of the high standard achieved by American and continental tools, but is dictated purely by limitations of space.

The machine which is illustrated by Figs. 1 and 2 is one that is used in large numbers by the carriage department of the Royal Arsenal at Woolwich. It is made by James Archdale and Co., Limited, of Birmingham, and represents their latest design of this class of tool. Two prominent features at once attract attention—first, the right angle belt drive; and, secondly, the long and stiff sliding head which supports the spindle close up to the cutter. Both these arrangements are now common in vertical machines, and it may be taken that they represent the standard design. The changes of spindle speed in the tool before us are six in number, obtained by a three-step cone and a back gear on the spindle itself. The countershaft is further provided with a double speed, so that, in all, twelve changes of spindle speed are readily obtainable. The countershaft makes 300 or 400 revolutions per minute, and has pulleys 11½in. and 9in. diameter by 3½in. wide. A section of the spindle and driving gear complete is shown in Fig. 2. The spindle, it will be seen, is carried on a long sleeve running in the main bearings, through which it can slide vertically. The sleeve is driven either direct by the belt pulley A or through the double gear C D, the corresponding pair of wheels being behind and not visible in the drawing. B is the locking plate keyed to the pulley A; E is the locking bolt retained in or out by a spring catch. In Fig. 1 the lever for engaging the back gear is clearly shown. The whole thing is neatly boxed in. The lower end of the spindle is carried in an adjustable conical bearing fixed in the vertical slide. The construction of this bearing is of normal design, and is shown in section in Fig. 2. The same illustration exhibits the method of raising or lowering the spindle by means of an external hand wheel—see Fig. 1—keyed to a worm F, which revolves a long nut G on a screw fixed in the slide. A long screw with check nuts provides a vertical dead stop or adjustment for the vertical movement.

There are nine changes of feed, effected entirely by gear. The levers are placed conveniently at the side of the machine, and an ingenious graphical chart or indicator shows their correct relative positions for different rates. The mechanism is shown in section in Fig. 2.

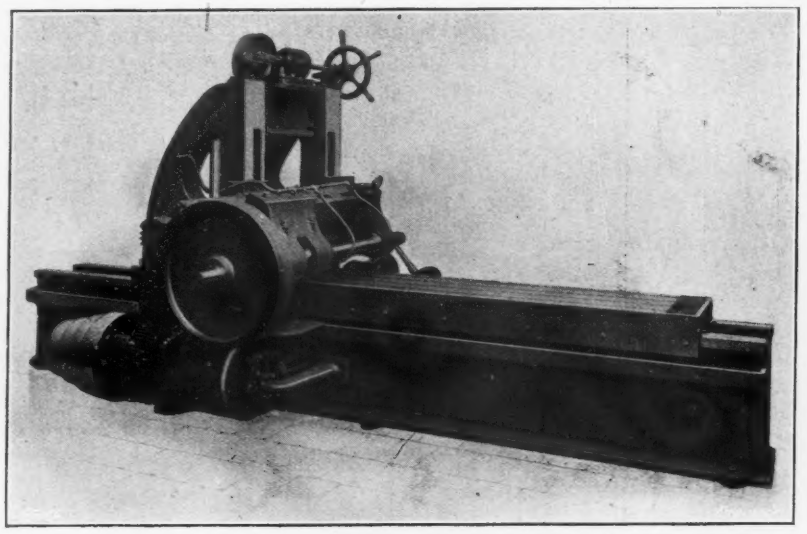


Fig. 9—SLAB MILLING MACHINE—J. BUTLER AND CO.

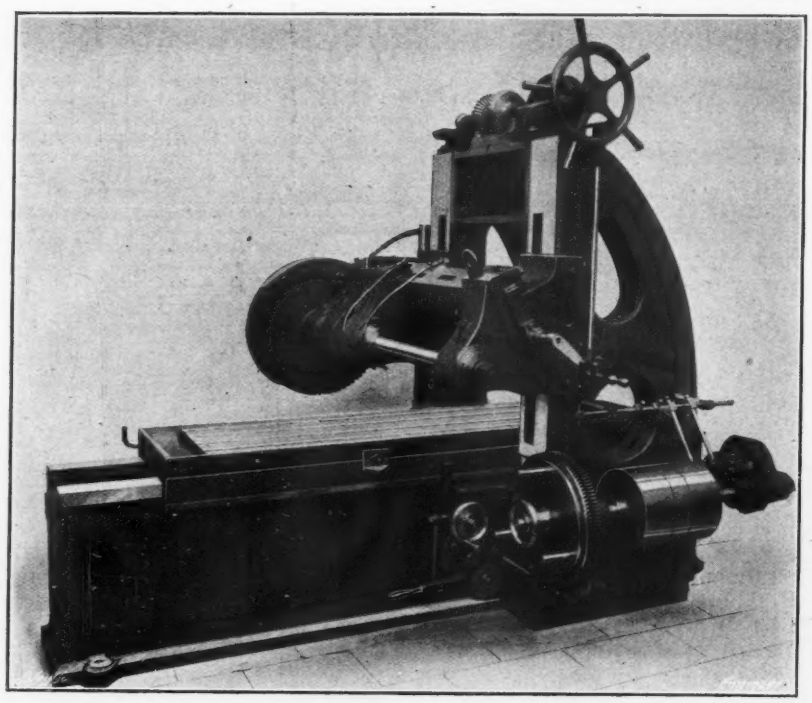


Fig. 10—SLAB MILLING MACHINE—J. BUTLER AND CO.

The drive is taken by a pulley at the top of the machine from a constant speed belt, and is wholly independent from the spindle drive, as recommended in our introductory notes. The gear box contains a nest of nine wheels on three shafts, those on the upper and lower shafts being loose, whilst those on the middle shaft are permanently keyed. A sliding feather in the upper and lower shafts permits any wheel of the three to be fast; thus for each wheel in the lower shaft which is driven by the reversing bevels shown three separate speeds of the upper shaft are obtainable, or nine changes in all. The feed shaft A is splined, and through gearing drives a worm and thence a wheel on a lay shaft, which, through a pair of equal wheels, revolves a nut on the feed screw. The whole arrangement can be very clearly seen in the drawing. This drawing also shows the clutches by which the cross and longitudinal feeds are engaged. The clutch is shown in the central position, and both gears are therefore out. The cross-feed screw is marked C. It is driven by a helical wheel D, which is keyed to the feed shaft when the clutch is thrown to the left; on the other hand, with the clutch thrown to the right, the worm wheel is fast with the shaft to which E is keyed, and the transverse feed is in gear.

The worm drives the movable part of the clutch, and

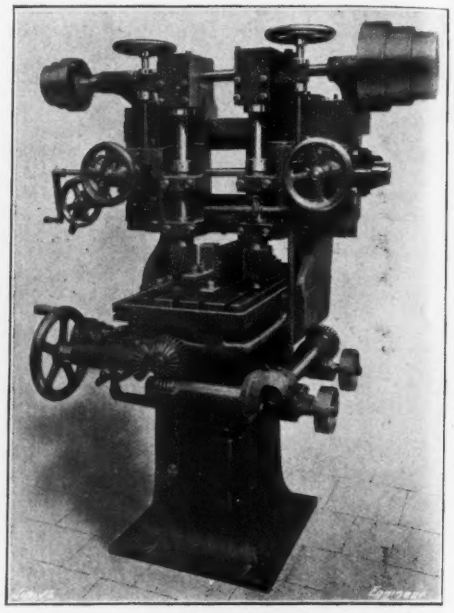


Fig. 11—TEST PIECE, MILLING MACHINE

hence when this is in its central position both hand gears are quite free. The same clutch is operated by the automatic cut-out motions, which throw it at predetermined places to the central position. The manner in which this is effected is as follows:—The shaft to which the clutch operating levers are attached has teeth cut on it at one place. Two plungers at right angles to each other are also provided with teeth which gear with those on the shaft. Hence, if either plunger is pressed in it causes the shaft to rotate and withdraw the clutch. One plunger is vertical, and its upper end has inclined faces. A knock-out bracket attached to the side of the table at any desired position has also an inclined face, which, as it passes over the top of the plunger, presses it down and stops the transverse feed. The arrangement of the longitudinal feed is slightly different. It is shown in Fig. 2. In this case the inclined end of the plunger fits into a notch in a bar which is moved endways by adjustable blocks locked on a rod fixed to the table. Besides these

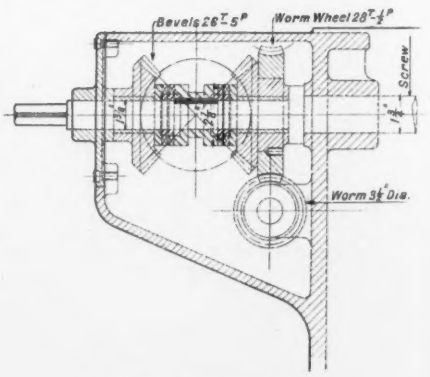


Fig. 12—REVERSING GEAR

automatic knock-out motions, positive stops, which are worked up to by hand, are provided. When desired, a self-acting circular table can be mounted, as shown in Fig. 1.

It will be noticed that all the locking bolts on the machine are provided with handles, and that no spanners are required. The wheels in practically all cases are graduated, and pointers are fixed in convenient positions. The machine will admit work up to 32in. diameter, and from the spindle to the rectangular table is 20in. The transverse travel by the table is 20in., and the longitudinal 10in.; the vertical adjustment is 18in.

We illustrate by a drawing a heavy horizontal milling machine, made also by James Archdale and Co., Limited. In many respects it is similar to that already described, but it will be seen that the nine feeds are doubled by a back gear on the horizontal shaft, giving eighteen changes in all, and it is driven from the main spindle. The main pulley has four steps, so that with a two-speed countershaft and a back gear sixteen speeds are obtained.

There is something particularly solid about the appearance of the vertical milling machine illustrated in Fig. 6, which is made by Sir W. G. Armstrong, Whitworth and Co., Limited, Manchester. The proportions of the main frame and the design of the balanced adjustable

vertical slide are such that vibration or chatter of the milling cutter is obviously non-existent. The spindle runs in adjustable bearings, and is driven by a cone pulley, vertical shaft, and single or double gearing. The vertical slide and spindle are counterbalanced, and can be securely locked. The table has self-acting and hand-feed motions from 1in. to 12in. per min. in both directions, and the variable feeds are connected and disconnected by levers. Convenience of operation has been duly considered in the arrangement of the hand wheels and levers

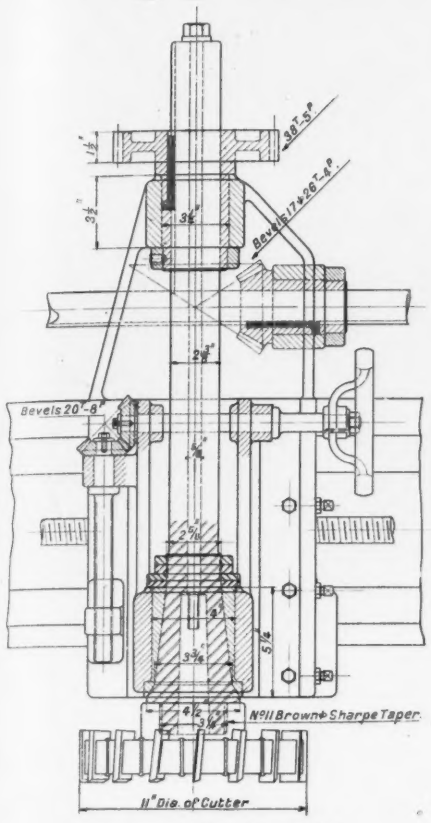


Fig. 13—SECTION OF SPINDLE

in the front of the machine. The table slides have self-acting adjustable tappet arrangements and brass index plates. The circular table is removable, to allow greater space for large pieces of work, and has self-acting and hand circular motions. The leading dimensions of the machine are as follows:—Diameter of spindle, 2¼in.; vertical adjustment, 2ft. 5in.; from face of circular table to under spindle socket, 2ft.; from face of rectangular table to under spindle socket, 2ft. 5¾in.; length of rectangular table, 5ft. 8in.; width of rectangular table, 1ft. 6in.; longitudinal traverse of table, 4ft. 1in.; transverse traverse of table, 1ft. 3¾in.; diameter of circular table face, 1ft. 8in. The spindle speeds are 16 in number; and range from 12 to 250 revolutions per min.

A heavy high-speed slab milling machine by the same makers is depicted in Fig. 4. The principal dimensions of this tool are:—Length, 17ft.; width, 9ft. 6in.; top table, length, 8ft.; width, 2ft.; height of work under 6in. cutter, 2ft. 5in. The machine is operated by means of a 40 horse-power motor running from 250 to 750 revs. per min. The cutter speeds are from 30 to 80 revs. per min., the table feeds from 1in. to 12in. per min., and the quick movement of the table 13ft. per min. The spindle is 5in. in diameter. The bed of the machine is heavy, and two strong uprights are bolted down to its face, being secured together at the top by a cross stay. The cross slide fitted on the face of the upright is adjustable for height by hand by means of the cross handle shown, bevel gear, and vertical screws. The front face of the cross slide is fitted on the right-hand side with an adjustable support for the outer end of the cutter mandril, and on the left-hand side with adjustable slide. The heavy steel spindle runs in phosphor-bronze conical bearings, and is driven by a large spur ring through spur and bevel gearing from the motor. To take the end thrust of the cutter the spindle is provided with a tail pin. The table has a quick-running motion in either direction, and is connected by a lever. It will be observed that all levers are convenient of access by the operator. In Fig. 5 is shown a motor-driven milling machine, designed for operating on the edges of armour plates. The machine consists of a massive cast iron bed with a feed screw inside. A milling headstock is mounted on a saddle, and can be adjusted longitudinally to bring the cutter up to the work. The milling headstock carries an octagonal slide in which is a heavy steel spindle running in conical bearings, and the spindle is driven by a 15-H.P. electric motor placed at the rear of the saddle, and spur gearing. To give different spindle speeds change gears adjusted by a hand wheel are provided. The spindle is capable of vertical adjustment. The milling head has a traverse of 30ft. along the bed. It has self-acting variable feeds to suit varying depths, and has a quick run motion in both directions. The quick run and feed gear are placed at the end of the bed and consists of a variable speed motor in conjunction with two changes of gear. There is a double clutch for throwing in the feed gear on one side, which consists of a large worm wheel, or into quick run gear driven more direct by spur gearing. The driving and feed motors can be started synchronously, but there are also separate switches. In this way either can be controlled independently of the other, so that any feed within the capacity of the machine can be used at any milling cutter or spindle speeds. Sir W. G. Armstrong, Whitworth and Co., Limited, are also the builders of the large four-spindle milling machine shown in Figs. 7 and 8. The massive cast iron bed carries a table with T-grooves on the face for holding the work. Two uprights are secured to the bed and tied together at the top by a cross-stay. A heavy cross slide is attached to the face of the uprights, and is fitted with two saddles carrying spindles 4in. diameter, which can be set at an angle for doing taper work. Each upright is also fitted on the front face with a saddle carrying a spindle slide which can also be set at an angle for taper work. The machine is driven by a countershaft, cone-pulley, and belt. From a pulley on the countershaft a belt passes round a 12in. pulley on the shaft, which runs across the top of the uprights, and at its other end is fitted a three-speed cone-pulley. A belt from the latter drives on to another three-speed cone at the back of the machine. On the same shaft as the latter cone bevel gear wheels transmit motion to a change gear box. The gears drive a revolving nut on the main screw in the bed, a nest of bevel gear wheels, with clutch placed conveniently for the operator allowing the direction of motion of the table to be controlled. A hand wheel placed conveniently on the bed also allows the workman to adjust the table to any desired position. A tappet motion fitted to the table enables the feed to be thrown in when desired. Besides the table feeds there are also provided self-acting feeds to the spindle slides on the cross slide, and these are obtained from the gear box previously mentioned, and a vertical gear-driven shaft on the side of the front upright. The cross slide can also be adjusted vertically by means of a quick-run arrangement. This consists of bevel gears between the countershaft and the vertical screws inside the uprights. The direction of movement is controlled by a lever placed conveniently for the operator.

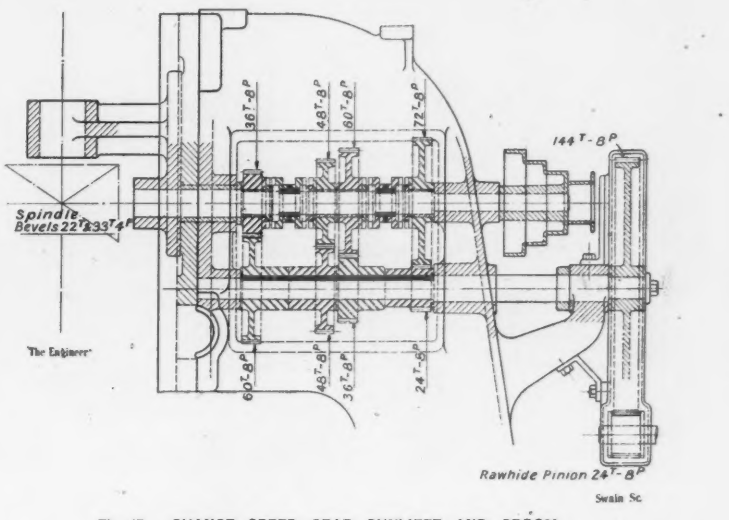


Fig. 15—CHANGE SPEED GEAR—CUNLIFFE AND CROOM

Each of the four cutter spindles can be adjusted by hand for position, and there is a motion for adjusting them vertically and horizontally. The general arrangement of the motions and gearing is clearly shown in Fig. 8.

The machine illustrated in Fig. 11, and made by J. Butler and Co., of Halifax, has been specially designed for milling flat test pieces, but it is clearly suitable for a variety of work. The construction is quite obvious from the engraving, and little need be said about it. The driving arrangement consists of a three-speed cone with steel worms and phosphor bronze wheels on the spindles. The slides are provided with vertical and horizontal adjustments, of which the latter may be made to each spindle separately or to both together; a slow adjustment for putting in the cut, with a dial showing the depth in $\frac{1}{100}$in., is also fitted. The table has quick hand adjustment and self-acting feed motion with automatic stop. It has three changes of feed by a speed cone. It is provided with special cramps for holding the test pieces, and any breadth from $\frac{1}{8}$in. to 9in. wide can be milled separately or a pile 4in. deep may be milled at once. The largest piece that can be milled with 4in. diameter cutters is 9in. wide by 4in. deep by 19in. long the face of the table is 14in. wide by 30in. long.

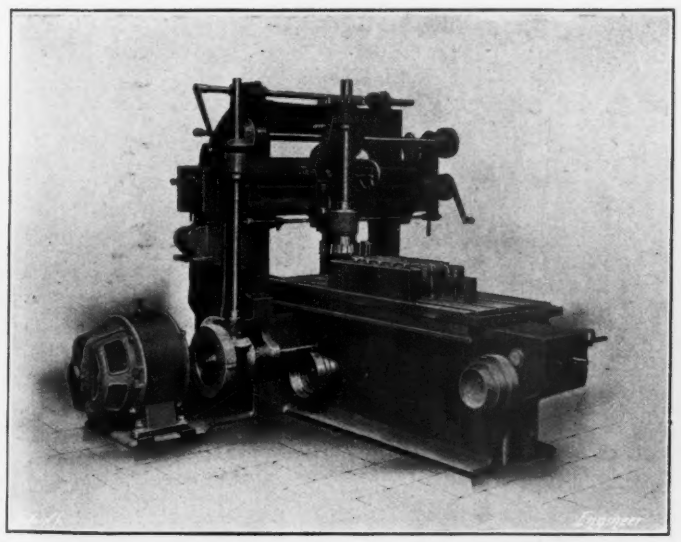


Fig. 14—PLANER TYPE MACHINE WITH VERTICAL SPINDLE—CUNLIFFE AND CROOM

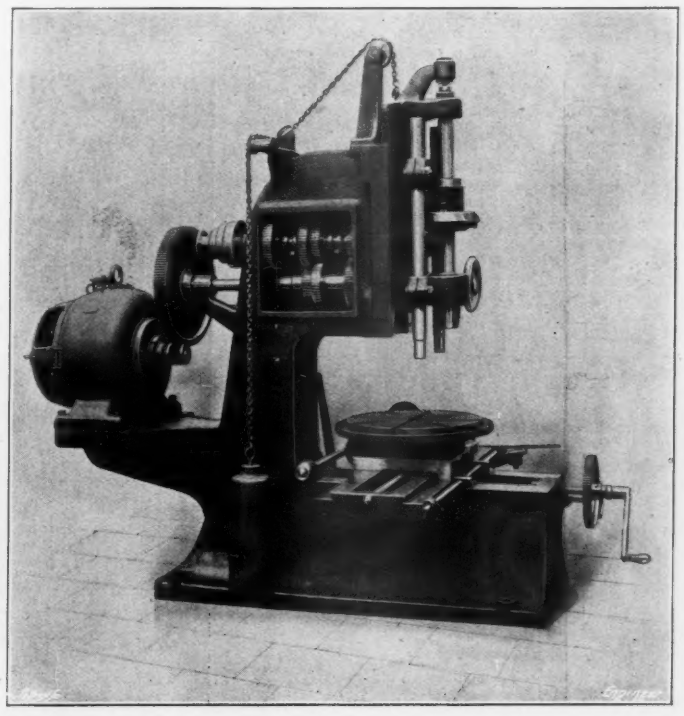


Fig. 16—VERTICAL MACHINE—CUNLIFFE AND CROOM

Two views of a large slab milling machine made by the same firm appear in Figs. 9 and 10. The machine is of substantial design, but it includes few special features, and the two illustrations leave little need for description. The driving cone gives four speeds, and has steps from 14in. to 20in. diameter, 4½in. wide. It drives a vertical shaft, which, through bevel gear, drives the pinion engaging with the large spur wheel on the cutter spindle. The feed change is effected partly by gear and partly by the friction plate seen under the great wheel in Fig. 9. It is transferred by a shaft to the opposite side of the machine, where through a set of change wheels it drives a worm wheel seen well in Fig. 10. This wheel can be coupled to the shaft on which it is mounted by the large friction plate shown. It then drives an inclined shaft with special gear which gives a steady feed varying between $\frac{5}{16}$in. and 10in. per minute. An automatic knock out holds the gear, seen in Fig. 10 in engagement, but drops it by the simple arrangement shown at any desired point. The belt pulleys seen on the feed shaft in this view are for moving the table rapidly by power at the rate of 30ft. per minute. The two outer pulleys are loose, and when this gear is in use the friction clutch is, of course, released. Power elevating gear for the cross slide is also provided, and a screw for end adjustment of the loose spindle bearing is fitted. The slide is inclined at a suitable angle better to receive the stresses due to the cut.

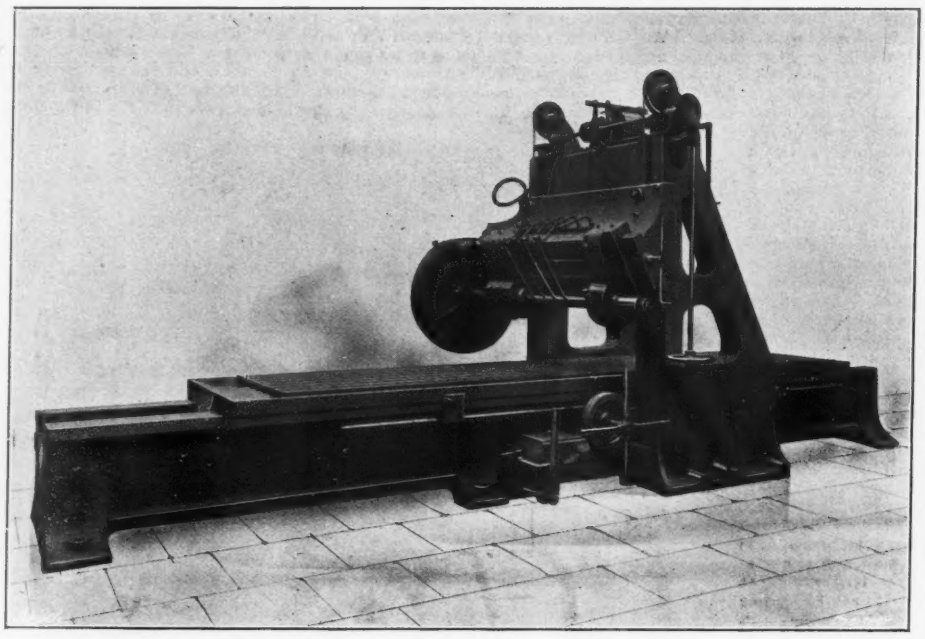


Fig. 17—SLAB MILLING MACHINE—CRAVEN BROS., LTD.

Fig. 14 represents a motor-driven machine of the planer type with vertical spindle, made by Cunliffe and Croom, Limited, Manchester. The table is 5ft. long, and has a traverse of the same length; the width between the uprights is 2ft. 6½in.; the traverse of the spindle along the cross slide, 2ft. 6in.; the depth under the spindle nose, 1ft. 10in.; and the diameter of the spindle in the body, 2⅞in. In the illustration the machine is shown as arranged for machining the halves of aluminium crank cases and gear boxes for motor cars. The spindle, a sectional view of which is given in Fig. 13, runs in a conical bearing, and has means of adjustment for wear. The spindle slide has a self-acting feed horizontally in both directions along the cross slide, with automatic trip to each traverse. The table has also automatic traverse and trip motions in both directions. A detail sketch of the clutch motion for reversing the self-acting travel of the table is shown in Fig. 12. We are informed that when working on aluminium feeds up to 20in. per minute can be taken at a cutting speed of 500 per minute.

Fig. 16 represents a motor-driven vertical machine by the same makers. It is shown with the cover of the gear case removed, and a sectional drawing of the gearing is given in Fig. 15. A raw hide pinion with twenty-four teeth, eight pitch, gears with a spur wheel of 144 teeth on the countershaft. Four spur wheels on this shaft mesh with corresponding wheels on the upper and parallel shaft, any one of which can be secured on its shaft at will by jaw clutches shown. On the end of this shaft is secured a bevel wheel gearing into a corresponding bevel wheel on the spindle. By this arrangement four spindle speeds are available, namely, 38, 66, 111, and 185 per minute. The spindle runs in an adjustable conical bearing, and is carried in a vertical slide. The spindle slide is adjustable vertically by hand wheel, worm and rack, and is balanced. Compound slides are provided, and the circular table has self-acting rotary motion. All traverses are capable of being reversed. The machine is made in three sizes.

The distinctive feature of the slab milling machine—Fig. 17—built by Craven Brothers, Limited, Manchester, is the angular arrangement of the cross slide face upon which the main spindle headstock is mounted. The builders' idea in adopting this arrangement is to give greater stability and more effective resistance than usual to the pressure due to the cut. The main spindle is carried in two capped bearings, the inner one being of extra length, and adjustable on the cross slide by screw and handle, by which it can be securely locked. The spindle is prepared to receive the cutter mandril, and an outer adjustable bearing is provided for the end of the mandril. The cross slide is balanced, and can be adjusted vertically by power or hand motions. The drive is through a wide four-speed cone pulley at the back of the machine through two changes of gear, giving eight speeds to the cutter spindle, and the power is sufficient for high speed steel work. The self-acting motion for the table is positive, and provides eight gear changes by means of a conveniently placed lever. Adjustment of the table can be made by either hand or power, and an automatic stop motion is provided to arrest the traverse at any given point of the table's travel. The maximum stroke of the table is 15ft., the width between the standards 3ft. 9in., the height from the top of the table to the under side of a cutter 10in. diameter 2ft., the diameter of the main spindle in the parallel part is 5in., and the diameter of the mandril to receive the cutter 3½in. Such a machine is well adapted for operating on locomotive coupling and connecting-rods. Fig. 18 represents a vertical milling and profiling machine, built by the above makers. The bed is a massive casting prepared for the reception of the main frame, table, and slides, and is also shaped to act as a receptacle for the cutting lubricant. The spindle slide is balanced and provided with a self-acting feed motion for drilling and quick adjustment by hand. The circular table has self-acting motions for longitudinal, transverse, and circular movements, with a reversing motion to operate the feeds in either direction, and quick hand adjustments. When used for milling by the aid of a former the bottom slide is free to travel in or out from the main frame, and the former, which is mounted on the table, is forced by a balance weight against a roller on the milling cutter support. In this way the desired shape is given to the work. The machine is driven by means of a three-speed cone and spur and bevel gears on to the spindle, and sufficient power is provided to take advantage of the use of high-speed steel. The principal dimensions are as follows:—Diameter of steel spindle on body, 4in.; distance from centre of spindle to frame, 2ft. 5½in.; longitudinal travel of table, 2ft. 6in.; minimum distance between spindle nose and table, 7in.; maximum distance between spindle nose and table, 1ft. 9in.; diameter of table exclusive of dish, 3ft. 6in.

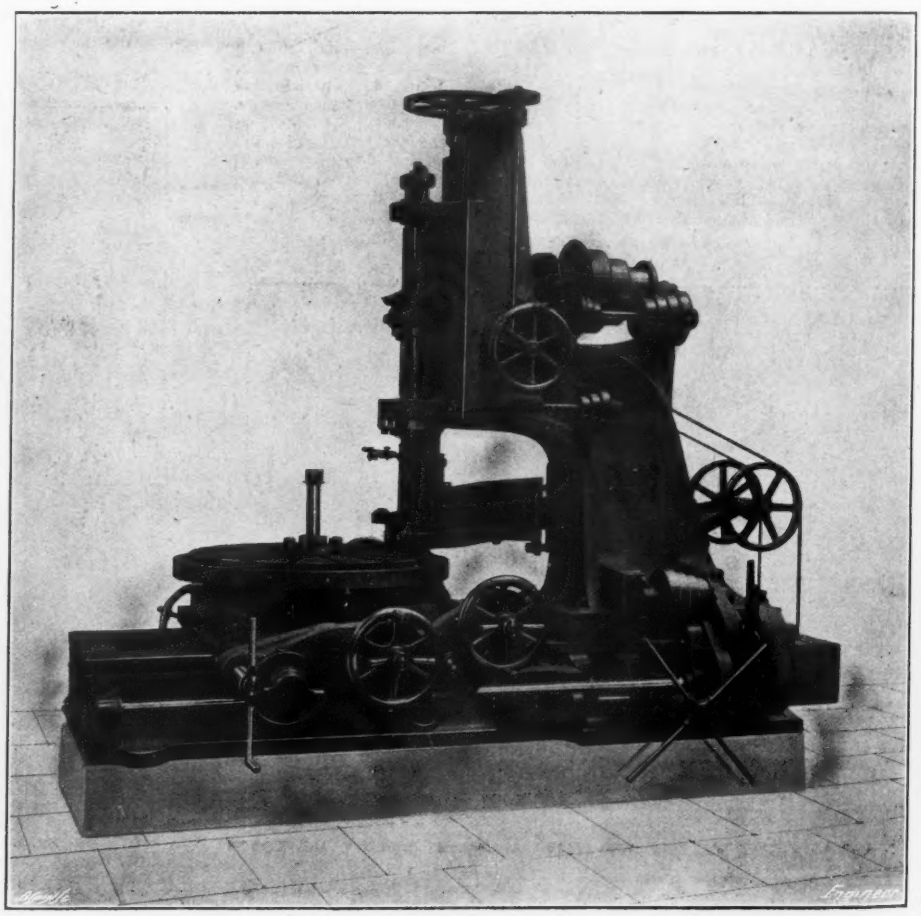


Fig. 18—VERTICAL MILLING AND PROFILING MACHINE—CRAVEN BROS., LTD.

Amongst the leading makers of tools of the kind we are discussing Alfred Herbert, Limited, of Coventry, hold a high place, a statement which will be understood at once by an inspection of the small selection of machines of their make illustrated by Figs. 19 to 26. The first of these is known as a No. 8 vertical milling and profiling machine. Two views of it are given—see Figs. 19 and 20.

This machine is intended for general engineering work, and is complete and modern in every detail. It is, we are told, being largely used by motor car engineers for milling aluminium crank chambers and gear boxes, the face cutter used for this purpose running at as high a speed as 800ft. per minute, with a feed of 16in. per minute.

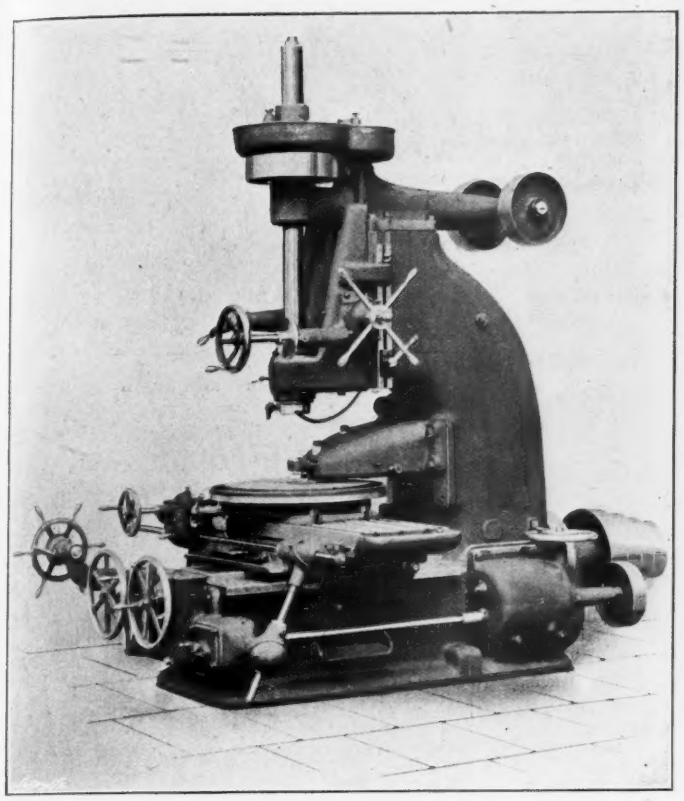
The main spindle has the features usually found in Herbert's machines. It has a clutch drive for the arbor, and the bearing is adjustable, and has a special lubricating arrangement. The spindle head is balanced, and can be raised or lowered by a hand wheel with micrometer disc at the front, or by the cross arms at the side, which give quick adjustment. It is locked in position by a taper gib, which is moved endwise by a rack and pinion clamping it very solidly, without any fear of disarranging the adjustment. An adjustable stop for determining its position vertically is seen in Fig. 19. The machine is driven by a belt passing from a pulley keyed to a stepped cone at the back over guide wheels to a pulley on the spindle, this pulley running on a fixed sleeve so as to relieve the spindle itself of all belt pull. The double gear, it will be seen, is entirely enclosed, and, in fact, there is not a gear in sight anywhere on the machine.

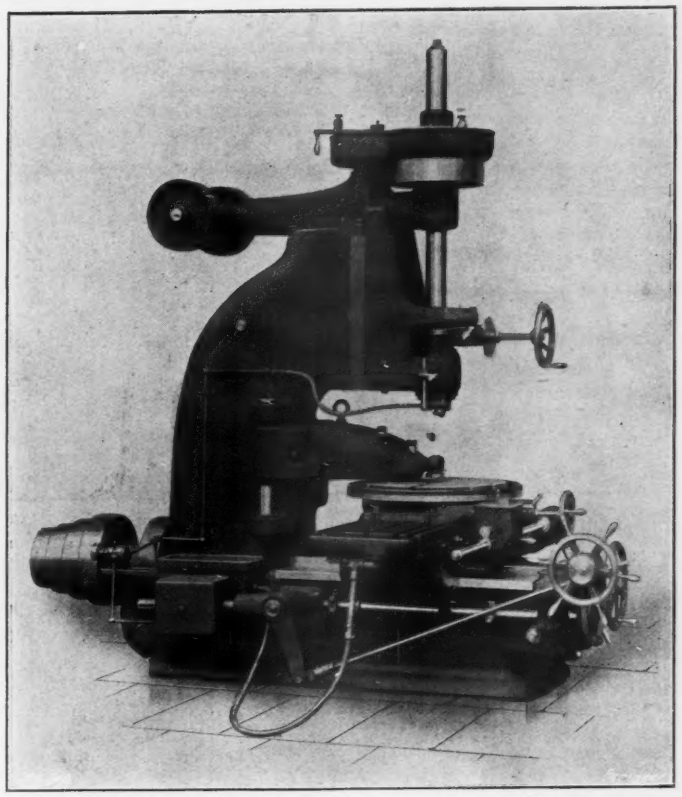
The steady bracket for carrying the lower end of the arbor when doing heavy milling, swings out of the way when not in use. It has two vertical positions, so as to come close to the main table or the circular table, according to which is in use. It carries, when the machine is fitted for profiling, a roller, the holder for which has screw adjustment for putting on the cut, this being operated by a hexagon-headed screw at the right-hand side of the

steady bracket—see Fig. 20. The adjustment of this profiling roller is quite independent of the support for the end of the arbor, and both can therefore be in use at the same time.

The main tables are provided with ample channels for containing and carrying away the lubricant, a covered way being provided as in horizontal machines by the same makers. Both longitudinal and cross movements have self-oiling slides, which we believe is a new feature on milling machines. The longitudinal movement is oiled by rollers similar to those used on planing machines, but for the transverse movement syphon lubricators connected with the tanks containing the rollers for the longitudinal slide are employed. The transverse slide is guided by a raised tongue in the centre, and it is held down by gib plates on the outside edges of the base—the guiding of the slide thus being performed by the central tongue, which is long in proportion to its width. The longitudinal and transverse adjustments are controlled by hand wheels on the front of the machine, and all the adjusting screws have large micrometer discs.

The feeds are automatic both longitudinally and transversely, and both are reversed from the front of the machine, and have automatic and dead stops. The latter are arranged to act after the automatic stop, thus rendering it impossible to break anything by feeding into the dead stop. The feed is varied by a dial feed box, which can be seen at the right-hand of Fig. 19. We refer to this box again later. Sixteen feeds are provided in either direction, the maximum feed for ordinary work being 12¼in., although the feed box is speeded up when required, as when aluminium is being dealt with. The circular table has automatic feed in either direction and an automatic stop motion; it is driven by means of a swinging telescopic shaft from the reverse box at the front of the machine—see Fig. 19. The feed is disengaged by dropping worms, which run in oil. The circular table is easily detachable, and when removed renders the whole length of the plain table available for long work or for long gangs of similar objects. The circular table has a trough all round it, and is graduated by degrees. This machine is sometimes furnished with a large rotating square table, which can be indexed into four positions, and is used for milling bulky work which cannot be covered by the traverses of the machine. One side of a piece of work can be milled and the table rotated through 90 deg. or 180 deg., as required, to do the other sides. This square table can be fixed either centrally with the main table or may be offset as required, and is very useful, not only for the purpose described above, but also for general use, as it gives ample space for clamping down the work. A profiling arrangement can be fitted when required. It is operated by a sliding block attached to the transverse feed screw, the block having upon its underside rack teeth which engage with a pinion, the pinion shaft being provided with a lever carrying a large rectangular adjustable weight,





Figs. 19 and 20—VERTICAL MILLING AND PROFILING MACHINE—ALFRED HERBERT, LTD.

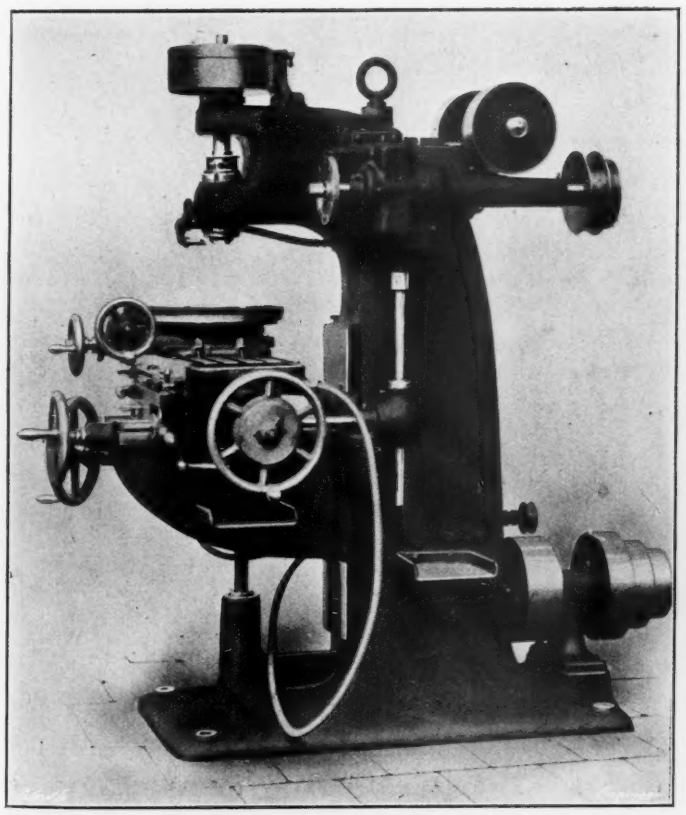


Fig. 21—VERTICAL MILLING MACHINE—ALFRED HERBERT, LTD.

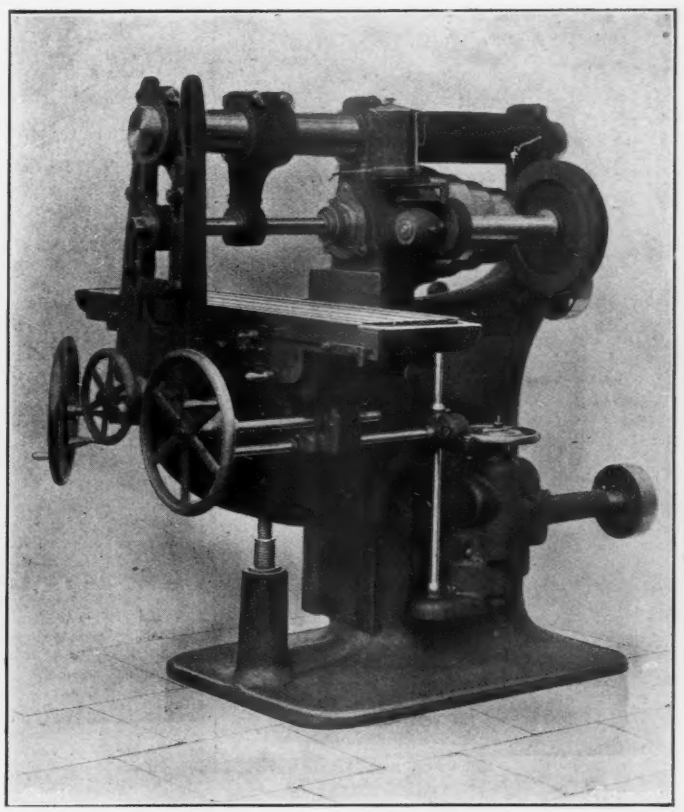


Fig. 22—HORIZONTAL MILLING MACHINE—ALFRED HERBERT, LTD.

seen beside the main column in Fig. 20. This lever has an additional arm provided with a long rod having rack teeth upon it, and these rack teeth gear with the pinion upon the mariner's wheel shown at the front of the machine. The use of this wheel is to relieve the weight when required, and to assist the cutter when the feed

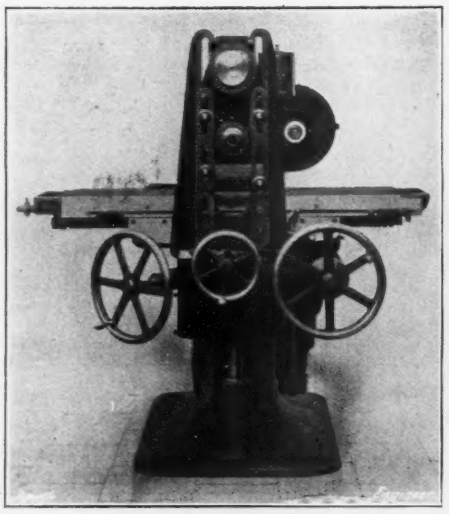


Fig. 23—HORIZONTAL MILLING MACHINE

becomes heavy through the irregularity of the work, or when ascending or descending steep inclines.

The following are the leading dimensions :—

Longitudinal feed	62in.
Transverse feed	38in.
Greatest distance from surface of table to spindle	26in.
Vertical adjustment of head	19in.
Working surface of table	72in. × 19in.
Diameter of spindle (body)	3¾in.
Diameter of spindle (main bearing)	5¼in.
Distance from centre of spindle to face of column...	25¼in.
Number of speeds	16
Number of feeds (from ¼in. to 12¾in. per minute)	16
Diameter of circular table over all	33in.
Diameter of circular table exclusive of oil dish ...	27in.
Height of circular table	6in.

The general design of the machine is excellent, and the details have been carried out with care and neatness.

In Fig. 24 the machine is shown arranged for milling completely round an irregular object, the profiling attachment being used in conjunction with the circular table. The position of the copy relative to the work above it and the method of supporting the end of the spindle are seen well in this view.

An example of a vertical machine used with a large ace cutter is shown by Fig. 26. Work of this kind, acing a G.P.O. junction box, can, it is claimed, be done better on a mill than on a planing machine.

A machine which has something in common with that just described, but is far smaller and lighter, is shown in Fig. 21. It is a No. 1 vertical milling machine, and is intended for comparatively light milling in engineers' workshops. The following are some of its leading points:—A right-angle belt is used as before, and the spindle is driven either direct or through epicyclic gearing contained within the pulley. The spindle, which runs in a sleeve, is bored through, and has a clutch drive for the arbor. The lower spindle bearing is adjustable, and has special means for lubrication, consisting of a channel which can be filled with oil, which is then conducted by

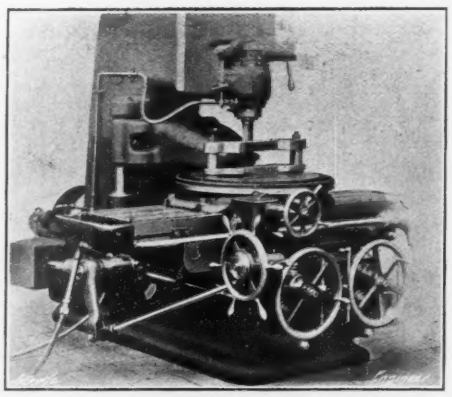


Fig. 24—PROFILING ON VERTICAL MACHINE

suitable grooves to all parts of the bearings. The channel is closed by a plate immediately above the lock nuts. The body casting has a large base, rendering the machine very steady, and is provided with an eyebolt at the top for slinging purposes. The operating hand wheels are all within easy reach of the operator, and every adjustment has a graduated micrometer dial. The hand wheel at the right-hand end of the table multiplies the motion of the feed screw by means of an internal wheel and pinion, giving a quick return motion, and the other end of the table has a hand wheel directly on the end of the screw, giving a slow motion for fine feeding. The slides are lubricated from the sides so as not to disturb the work when the table needs to be oiled. The dial feed motion gives nine feeds, obtained by simply rotating the disc to the desired point, the feeds in inches per minute being marked consecutively round it. The knob or knurled handle seen in the centre of the dial controls the direction of the feed, being pulled out or pushed in according

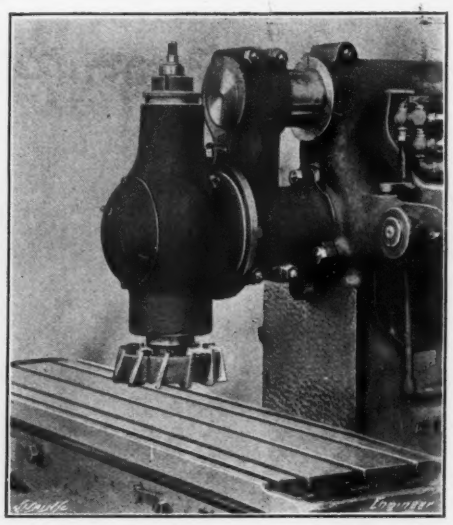


Fig. 25—FACING ON HORIZONTAL MACHINE

to the direction required. The circular table is detachable, and has quick and slow hand feeds, and is graduated. The knee has an extended slide and adjustable vertical stops up and down. The longitudinal feed of this machine is 30in., the transverse adjustment 12½in., the vertical adjustment 17in. The spindle pulley for a 3in. belt is 10½in. diameter. There are six spindle speeds and nine feeds, from ¾in. to 10½in. per minute.

We now turn to the consideration of the horizontal machine illustrated by Figs. 22 and 23, which is the largest size of a series of three machines which are identical in their leading features, and has longitudinal and transverse feeds of 42in. and 12in. respectively. The body, head, and base are in one casting, whilst the sleeve in which the overhanging arm fits is a tube connecting front and back bearings. By this arrangement a very strong and stiff machine is secured. Carrying out this idea of complete box forms, the usual cupboard in the body has been dispensed with, as it is considered that to cut large holes in a box casting is to sacrifice its advantages. Four external trays, which are considered more satisfactory than cupboards, since they cannot hide rubbish and tools that ought to be returned to store, are provided instead. The spindle has an adjustable conical bearing at the front, and an adjustable parallel bearing behind. It is bored through, and has a clutch drive for the arbor, but the nose is also threaded so that large face cutters can be screwed upon it, and a cap is provided to protect the thread when not in use. A facing is provided round the spindle nose for the vertical milling attachment and similar devices. The spindle runs in the right-hand direction, enabling twist drills and reamers to be used when desired.

The cone pulley and back gearing give sixteen speeds in geometrical progression. The method of dividing up the speeds which has been adopted gives the largest possible diameter to the small step of the cone pulley, thus avoiding weak places in the speed range. Every gear on the machine is covered. The table is unusually thick, to prevent distortion by the clamping of work, and, as in the machine just described, it is oiled from the side. This is a feature of great importance in cases where machines are used for a long time on repetition work with fixtures permanently attached to them. A covered way is provided from end to end of the table to connect the two pockets, so that there is a free passage for the lubricant to find its way back to the tank, even when the table is heaped up with chips. The cover can easily be removed from this channel for cleaning. The long feed screw in the table does not rotate, and is always in tension. The table is driven by a long phosphor bronze revolving nut and steel spur gearing, not bevel gearing, which the makers considered too weak. The knee is completely closed in underneath, giving a very strong form, and its bearing on the column extends above the planed surface of the knee, thus gripping the column in the most advantageous position, and giving a long guide.

The various movements of the table, backward and forward, to and from the column, and up and down, are

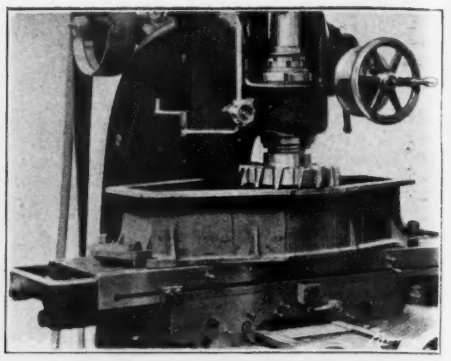


Fig. 26—FACING ON VERTICAL MACHINE

actuated by hand wheels (placed on the front of the machine), which are, it is claimed, superior to cranks, in that they can be grasped at any part when making adjustments. Every hand wheel shaft is furnished with a large micrometer disc graduated to thousandths of an inch, or divided metrically. The elevating screw for the knee is, it will be seen, telescopic, thus dispensing with the necessity of boring holes in the floor to admit it. The feeds can be driven either from the countershaft or from the spindle. Changes are effected by dial feed motion—so-called from the hand wheel with dial which regulates its changes. The dial consists of a brass plate round which the various feeds are marked in consecutive order, and to change from one feed to any other it is only necessary to rotate the dial until the number upon it corresponding to the feed required comes opposite the pointer. This can be done either while the machine is at rest or in motion. The motion is transmitted from the feed box to the table by means of vertical and horizontal shafts coupled together by enclosed spiral gearing running in oil. The horizontal shaft is geared to a swinging worm box which transmits its motion to the revolving nut driving the table through the medium of a worm and wheel and a train of three spur gears. The feed is tripped by the worm dropping out of gear, and when it is released the table remains fixed in position owing to the fact that the screw and revolving nut give an irreversible drive. In addition to the automatic stop for tripping the feed, the table has two dead stops, one in each direction. When the feed is driven from the countershaft, the latter

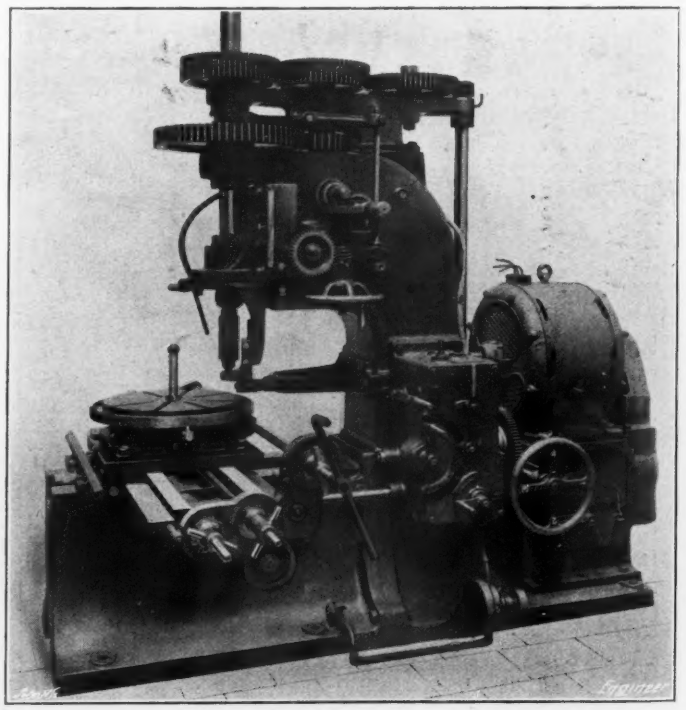


Fig. 27—VERTICAL MILLING MACHINE—JOHN HETHERINGTON & SONS, LTD.

is arranged so that the feed always stops when the machine is stopped, and when driven from the spindle the feed pulley, from which it receives its motion, is geared to twice the speed of the spindle so as to give ample belt power. There are sixteen spindle speeds between 10·5 and 494 revolutions per minute, and with a double speed countershaft, sixteen changes of feed. The overhanging arm is solid steel 5in. in diameter.

For performing vertical milling operations on the horizontal milling machine, the head shown in Fig. 25 is attached. The spindle is driven by steel bevel gears connected to the main spindle by a flexible drive. The

head is graduated, and can be revolved through a complete circle in a vertical plane.

A large double-head vertical spindle milling and profiling machine driven by a constant speed electric motor is shown in Fig. 34. This is a type of machine made in three sizes by John Hetherington and Sons, Limited, Manchester. The bed has flat sliding faces to receive the table, machined side pockets to receive the uprights, and a drain trough tank for the tool lubricant. The table is of ribbed section, with ⊥ slots planed out of the solid and drain trough cast all round. It has a quick power motion in both directions by means of a hand lever, friction clutch, bevel, and spur gearing, square-threaded steel screw and adjustable gun-metal nut. The uprights are of box section with ample bases, fitted and bolted to the bed and cross-stay. The cross slide is arranged with pulleys and brackets for balancing purposes through screws and gearing on each upright, and is elevated and lowered by fast and loose pulley and spiral gears. No weights are employed for balancing. The spindle carriages on the cross slide are mounted on antifriction rollers and are quickly adjusted transversely by hand through star wheels, spur gearing, pinions, and rack. For finer adjustment hand wheels and square-threaded steel screws are fitted. The feed screws are provided with gun-metal disengaging nuts. The hard steel spindles revolve in double coned adjustable gun-metal bearings, the bottom bearings and spindles being supported in adjustable slides with setting-up strips and locking arrangement. A vertical traverse is provided by hand wheel, worm, and mitre gearing, pinion and rack. From the motor power is transmitted through two speed change gears and four-step gear cone, bevel and spur gearing, with instantaneous change from double to quadruple gear. The feed motions for the spindle carriages and table are self-acting and variable through gearing, and can be changed instantly while in motion by means of an indexed hand wheel, giving a variation of eight feed speeds to each of the sixteen spindle speeds. For profiling work pulleys and weights and adjustable hardened steel cones carried from projecting arms cast with the spindle slides are fitted. A removable circular table is fitted on the main table. It is mounted on a

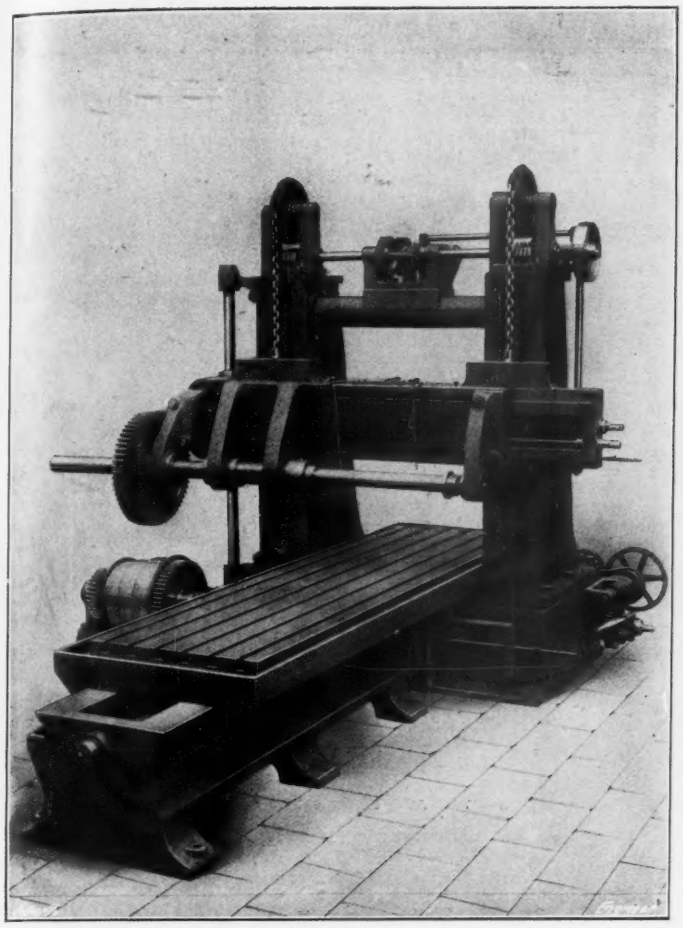


Fig. 28—PLANER TYPE MILLING MACHINE—HULSE & CO., LTD.

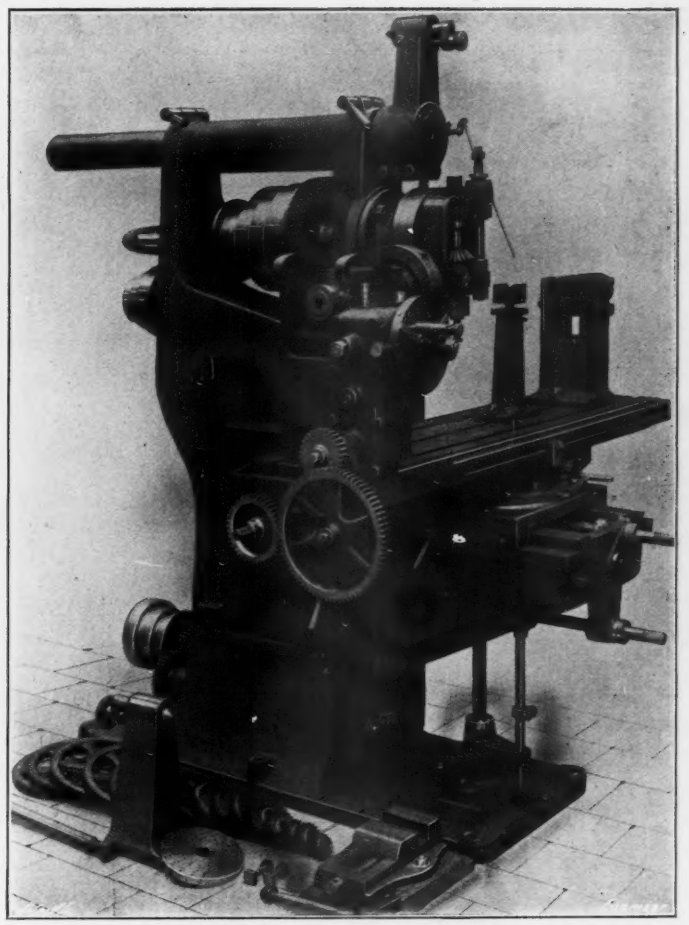


Fig. 29—UNIVERSAL MILLING MACHINE—HULSE & CO., LTD.

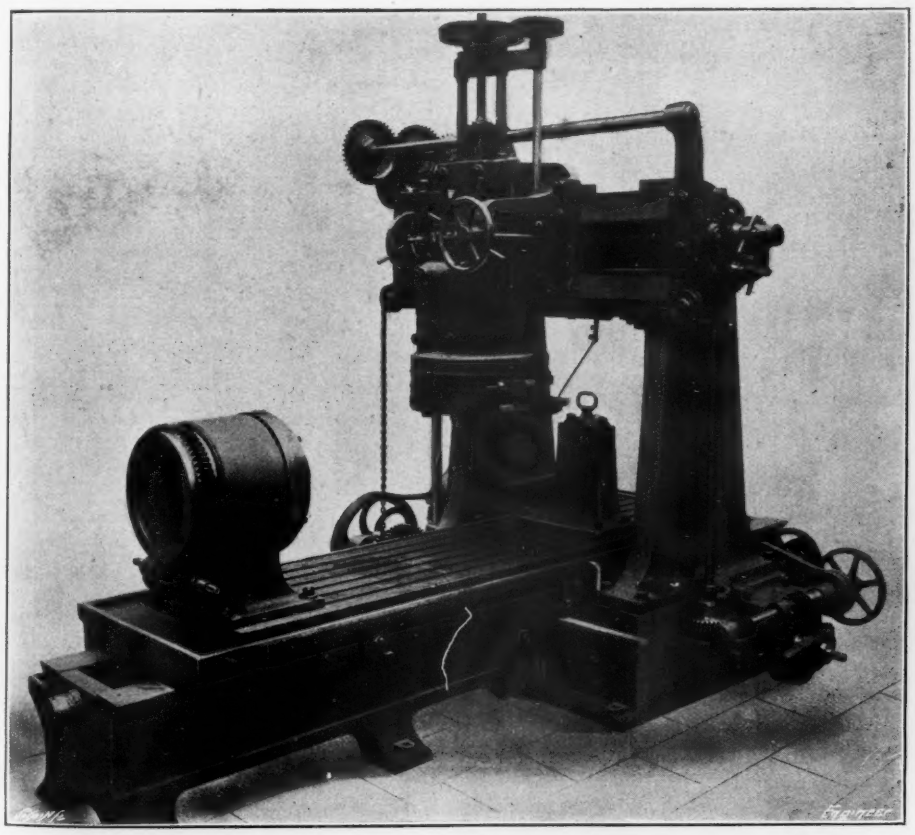


Fig. 30—MACHINE FOR MILLING ORDNANCE—HULSE & CO., LTD.

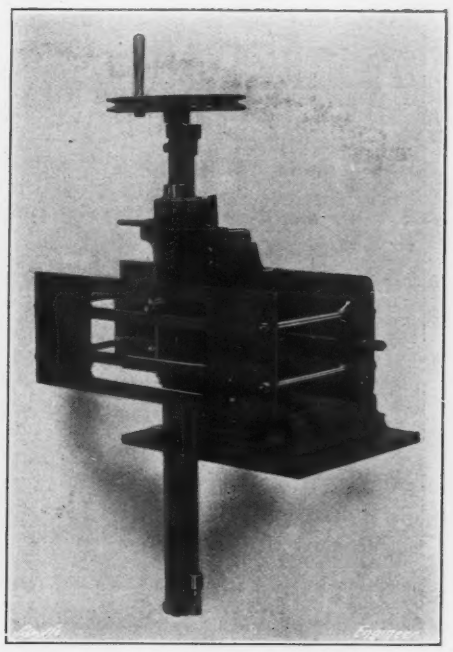
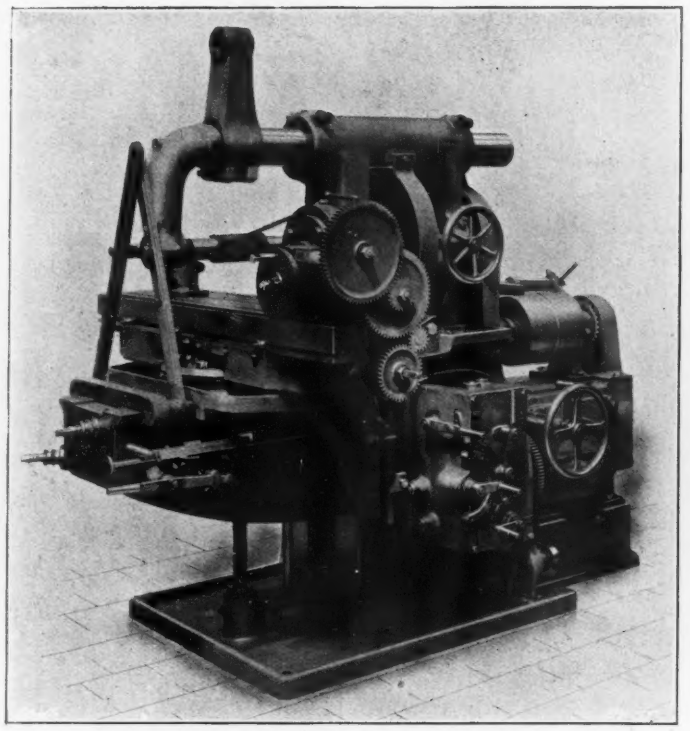
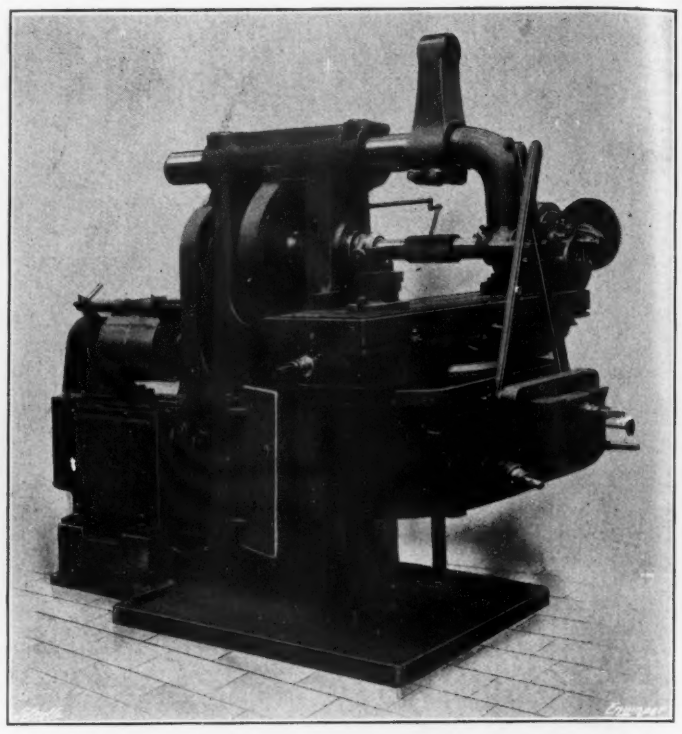


Fig. 31—PORT MILLING MACHINE





Figs. 32 and 33—UNIVERSAL HIGH-SPEED MILLING MACHINE—JOHN HETHERINGTON AND SONS, LTD.

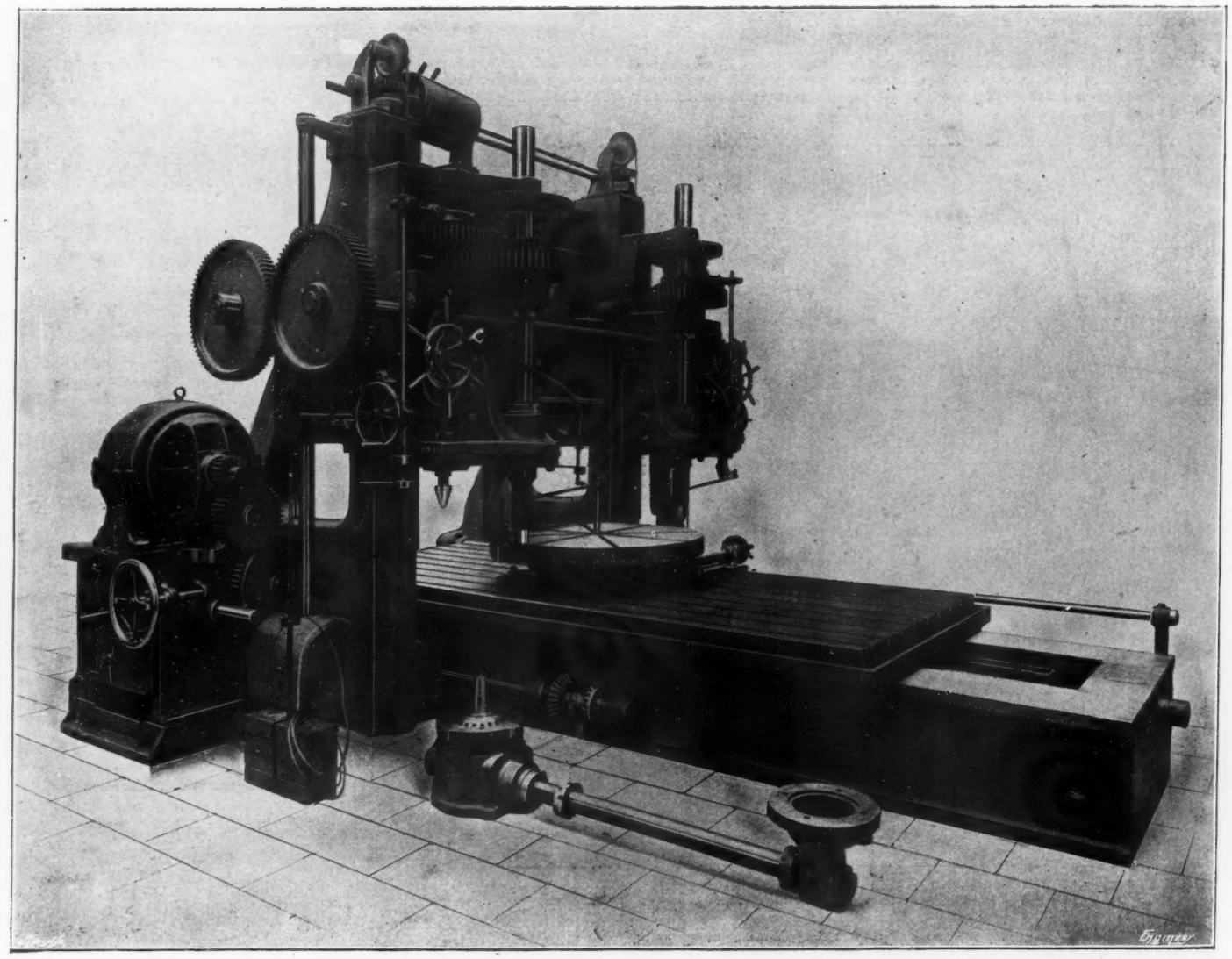


Fig. 34—DOUBLE-HEAD VERTICAL SPINDLE MILLING MACHINE—JOHN HETHERINGTON AND SONS, LTD.

square base which is bolted to the table, and is fitted with four locking clamps. The circular motion is coupled up to the main feed by means of spur and worm gearing, and has a quick hand adjustment. A machine of this type having a table 20ft. by 6ft., and with a clear space

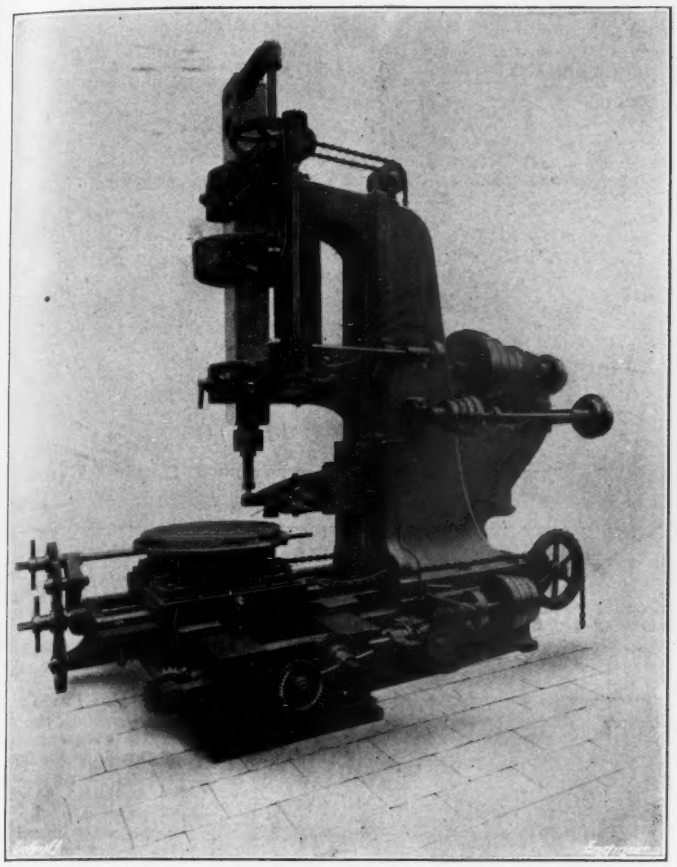


Fig. 35-VERTICAL MILLING MACHINE—HULSE & CO., LTD.

of 7ft. 1in. between the uprights, is being built for one of the Colonial Government railways.

Hetherington and Sons, Limited, are also he makers of the high-speed vertical milling and drilling machine shown in Fig. 27, in which the upright and front bed are

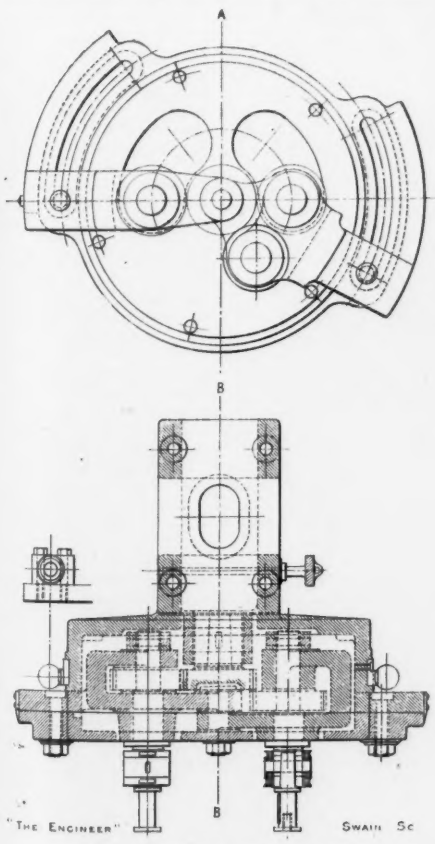


Fig. 36—SPECIAL MILLING HEAD

made in two pieces of box section machined and bolted together. In the illustration the machine is shown driven by an electric motor fixed on top of the cone gear box. The various changes of gear are effected by means of an indexed hand wheel and levers giving sixteen spindle speeds arranged in geometrical progression. The cutter spindle is fitted with Muir's patented coupling revolving in double-coned adjustable gun-metal bearings. The bottom bearing and spindle are carried in an adjustable slide, which is fitted with a swivelling mandril stay, setting-up strip and locking arrangement, and has a vertical traverse by hand wheel, worm gearing, pinion and rack. There is also a variable self-acting drilling feed motion by means of duplex worm-gearing and rack and pinion, which can be changed while in motion by an indexed drag rod giving three speeds to each of the sixteen spindle speeds. An instantaneous disengaging gear and hand feed are further provided. The circular, transverse, and longitudinal self-acting feed motions are variable, continuous, and positive, being effected by cut spur gearing. The self-contained feed gear box shown enables the feeds to be instantaneously started, changed, or reversed while in motion by indexed levers giving eight variations of feed to each of the sixteen spindle speeds. A quick adjustment of the table slides by hand or power is arranged for in front of the machine, so that the attendant has all motions under control without moving his position. The machine is made in three sizes, with 3in., 4in., and 6in. spindles. The universal high-speed machine shown in Figs. 32 and 33 is made for either belt or electric motor driving, and is a very powerful tool of its type. The frame is of box pattern for carrying the spindle gearing and overhanging arm and knee bracket. The frame is also designed to form a cupboard with adjustable shelves and hinged door. The spindle has a Muir's coupling, and revolves in adjustable double-coned gun-metal bushes. The overhanging arm has its outer end coupled to the knee bracket by removable adjustable stays. It has also an intermediate support for use with a long mandril. The machine has a longitudinal slide and a transverse swivel slide and a table indexed to 90 deg., that is 45 deg. each side of the spindle. Adjustable automatic knock-off motions are fitted to the vertical, longitudinal, and transverse slides, and each is provided with a micrometer disc adjustable to $\frac{1}{1000}$in. Sixteen changes of spindle speed are possible in geometrical progression by indexed hand wheel and levers, and the feed motions number eight. The machine with 4¾in. spindle has a vertical traverse of table of 20in.; longitudinal traverse, 10in.; transverse traverse, 44in.; and a maximum distance from the centre of the spindle to the face of table of 21in.; the maximum length of mandril is 24in.; the range of self-acting feeds is from ¼in. to 6in. per minute; and the variation of cutting speeds, approximately, 30ft. to 100ft.

A machine of the planer type which is capable of removing a large amount of metal in a small space of time is shown in Fig. 28. It has been specially designed by Hulse and Co., Limited, Salford, Manchester, for operating on locomotive connecting-rods and coupling rods, and is powerfully geared. The cutter arbor is supported in strong brackets, and the slide is adjustable transversely upon the cross slide, which is counterbalanced, and may be raised or lowered by hand, or, if desired, by power, as shown. The table is traversed upon the bed either rapidly by power for adjusting purposes, or through suitable gearing for the feed. A variable feed motion is provided to permit of the rate of feed being reduced when the heavy work of milling out the corners or curves of connecting-rods at the big ends is to be dealt with. Automatic stop motions to the feed are provided, and also efficient means of supplying a constant stream of lubricant to the cutters. We are informed that the machine illustrated has removed as much as 12 cubic inches of steel per minute. In Fig. 30 is shown a special machine of the planer type which Hulse and Co. have built for milling the ribs at the sides of the new 12 and 18-pounder field guns. It is also intended to perform drilling and profiling operations. The chief feature of interest is the special head fitted with two spindles, the distance between the centres of which is variable from 8in. to 12in. This arrangement is patented by Mr. A. S. Angas, of Woolwich, and is clearly shown in the sectional illustration Fig. 36. The machine is driven by a variable speed electric motor through the medium of a silent chain, and the special duplex milling head is readily removed when the machine is required for ordinary work. The spindle is carried on a square bar to eliminate overhang in a similar manner to that employed in Hulse's vertical milling machines. Reversible feed motion is applied to the spindle slide upon the cross slide and to the table upon the bed, the latter being also provided with quick power traverse in either direction. For profiling work the nut at the back of the spindle slide is readily disengaged. Upon the table is fitted a removable apparatus for supporting and rotating the gun while under operation. Steel rules with decimal graduations are fitted for indexing purposes, and provision is made for efficient lubrication of the working parts and cutters. Fig. 35 represents a heavy vertical milling, boring and profiling machine, which is typical of Hulse and Co.'s standard practice. In addition to performing ordinary operations, the machine is made particularly rigid, so as to be able to undertake special operations such as gun breech milling when a bottom stay for the spindle is not permissible. The outstanding feature of this machine is the employment of a heavy square bar which has adjustable conical bearings at either end for the reception of the spindle. This bar is adjustable vertically, either by power, for boring purposes, or by hand for regulating the position of the cutter, the advantages claimed for this arrangement being that support is always afforded to the cutter arbor immediately above it, and the absence of overhang. To allow for considerable vertical adjustment

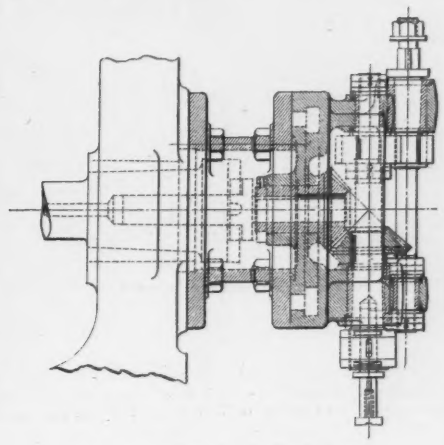


Fig. 37-ANGULAR MILLING HEAD

the spindle is driven by a spur wheel gearing into, and driven, in the case of the large machine illustrated, by a pinion sliding in a vertical shaft, and in the case of smaller machines, by a long pinion. When necessary a separate support for the lower end of the cutter arbor is provided. This is adjustable vertically by means of a screw and nut, and is arranged to carry the roller used for profiling. The roller is provided with a means of fine adjustment. Another feature noticeable is the provision of a lower table of square outline below the circular table, the latter being removable to allow of work of extra depth being dealt with. The machine is powerfully geared, and is fitted with reversible self-acting feed motion in the longitudinal, transverse, and circular directions. There is also a vertical motion to the spindle bar for boring, &c., while the nut under the square slide may be thrown out of gear when profiling work is being done. The machine is made in sizes ranging from 1½in. to 6in. diameter of spindle. In Fig. 29 is shown a powerful universal milling machine by Messrs. Hulse and Co. It is intended for dealing with work of large diameter, and is specially designed for cutting teeth in spur, bevel, and spiral gears, making milling cutters, fluting parallel or taper reamers, twist drills, taps, &c., for vertical or angular milling, rack cutting and other work. The machine is provided with a removable overhanging arm with a centre for the support of the cutter arbor, and the table is arranged to swivel. A removable universal dividing headstock, with vertical radial adjustment and the necessary swing

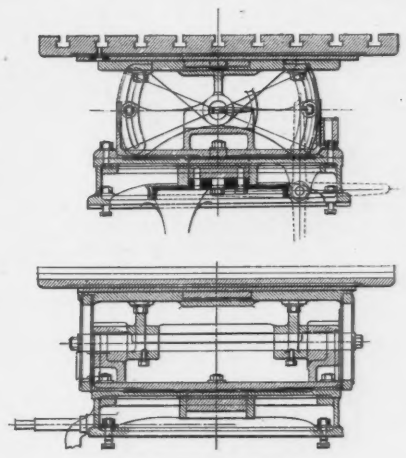
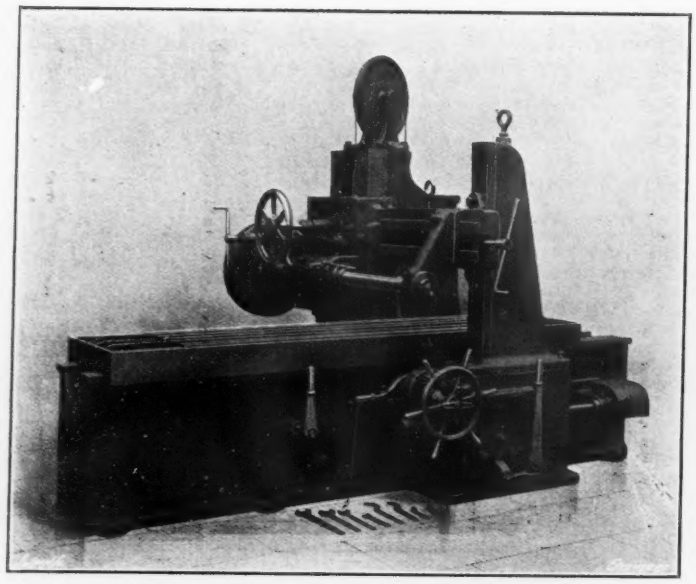


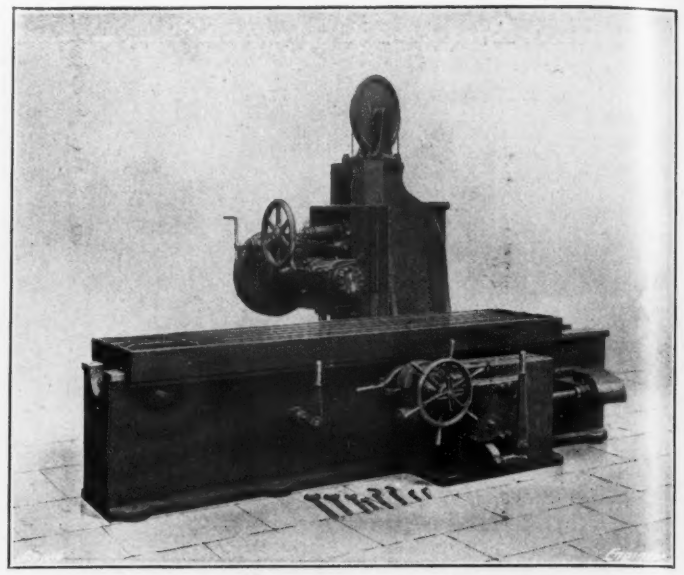
Fig. 38—TILTING TABLE

frame and change wheels for spiral work are mounted at one end. Two loose headstocks, one with radial adjustment, are also supplied. Adjustable stops are fitted for regulating the height of the table, and there is a variable self-acting feed traverse, with automatic disengaging motion, replacing the old-fashioned telescopic feed shaft and knuckle joints. An important addition to this tool is the removable vertical and angular milling device shown in detail in Fig. 37. This appliance may be readily applied, and having two spindles, is capable of dealing with a large range of work, such as cutting racks and the like. The construction of the apparatus will be

readily understood by reference to the drawing. The machine is driven by means of a wide belt and helical gearing, and means for efficient lubrication have been provided.

to be safely taken by the remaining upright this is considerably strengthened. The machine comprises a massive bed brought down to the floor line and provided at its upper surface with square guides on to which is gibbed the top or work table. This has T grooves along its whole length, with the exception of the ends, where fluid to the cutting point. A strong upright of box section is rigidly bolted to a facing on one side of the bed, and is formed with surfaced ways to receive the carriage which carries the cutter spindle. This carriage can be moved vertically by screw, nut, and hand wheel. A facing formed on the upright has the cross slide bolted to it. The other end of the cross slide is secured to the second and removable upright. The steel spindle is 3¾in. diameter in the body, and is swelled up to a conical bearing at the outer end, to which the cutter is fixed. This bearing is case-hardened and ground, and is self-adjusting by means of a double taper. The bearing for this end of the spindle is formed on a slide, moving in ways on the main carriage and having an in-and-out movement of 8½in. or more at right angles to the table. The spindle is driven by a four-step cone pulley fixed on a horizontal shaft geared by bevel wheels of twenty and thirty teeth to a vertical shaft alongside the main upright. Motion is transmitted from this shaft through a pair of wheels of similar size to those just mentioned and a spur reduction of sixteen and eighty teeth, ¾in. pitch, the large wheel being supported in a conical bearing on the main carriage and bored to suit the main spindle. This gives a total ratio of 11·2 to 1 from cone to spindle. The handle shown at the side of the bed controls the quick-power traverse motion of the table in either direction by means of levers and rods. This may be used when setting or running back after a cut has been taken, and is independent of the traverse for the time employed. For





Figs. 39 and 40—OPEN-SIDED PLANER TYPE MILLING MACHINE—KENDALL AND GENT, LTD.

Fig. 31 represents a portable milling machine designed by Messrs. Hulse and Co. for milling the ports of locomotive cylinders *in situ*, and is worked by either hand or power. The machine consists essentially of a frame, arranged to be bolted to the ends of the cylinder, provided with a slide, adjustable in two directions, and carrying a head with a long arm, made to rotate through 180 deg., so as to mill the ports of first one cylinder and then the other. This arm has at one end a suitable pulley, which drives, through a pair of spur gears and a long shaft, the worm gear giving rotation to the cutter, which is placed at the other end of the arm. Mounted upon the front of the slide is a small bowl, of equal diameter to the milling cutter, and which is used against a former, exactly reproducing the correct size of the cylinder ports.

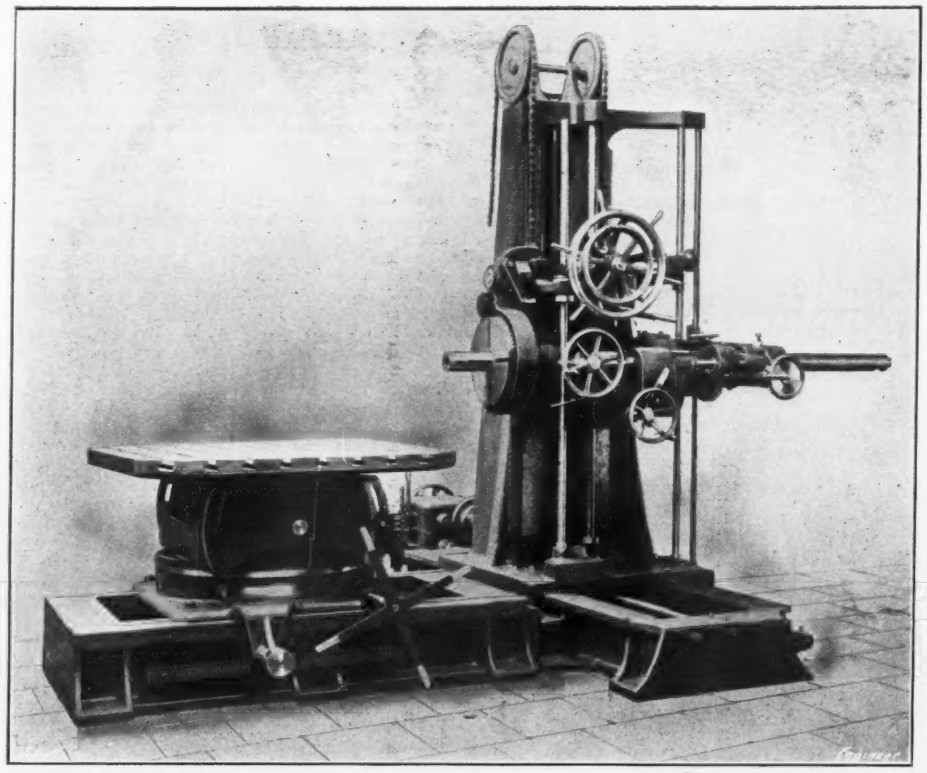


Fig. 41—MACHINE FOR MILLING LOCOMOTIVE CYLINDERS—KENDALL AND GENT, LTD.

A useful type of tool made by Kendall and Gent, Limited, Manchester, is shown in Figs. 39 and 40. As will be seen, it is an open-sided plano miller, designed primarily for dealing with articles not exceeding 9ft. long by 2ft. wide by 1ft. 6in. high. For work which cannot conveniently be dealt with between two fixed uprights the machine is arranged so that one upright can be removed, as in Fig. 40. The small cross slide used as a support for the outer bearing of the cutter mandril is also removable, leaving a clear space above and at one side of the table. To enable the whole of the working stress sud troughs are provided. These troughs are connected by short pipes to a channel, by which the liquid is led to a tank. From this a small belt-driven pump returns the

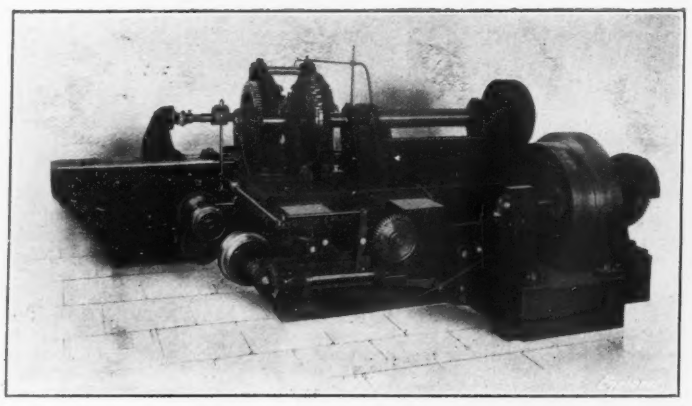


Fig. 42—CRANK SHAFT MILLING MACHINE—WILLIAM MUIR & CO., LTD.

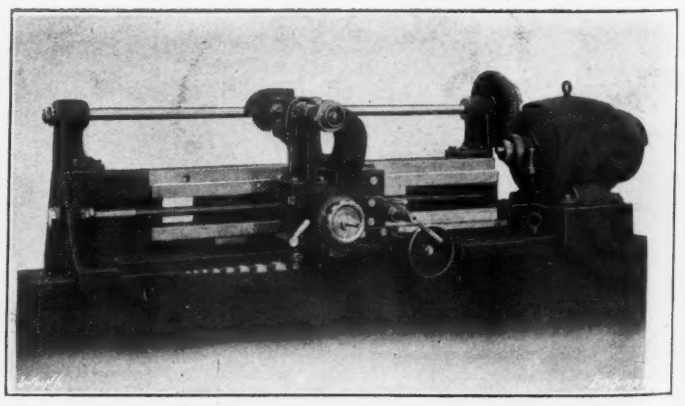


Fig. 43—TURBINE BLADE MILLING MACHINE—WILLIAM MUIR & CO., LTD.

the automatic power milling feeds motion is derived from a belt cone—not shown—by means of a shaft and mitre gearing to the horizontal shaft shown in front of the machine. This first traverses a reversing box consisting of a clutch and nest of three mitre wheels operated by a lever in the front of the box. A worm on this shaft then drives a worm wheel which, by means of a small handle, can be clamped to a cone clutch on a cross shaft passing through the bed and carrying the worm which actuates the worm wheel and nut on the table screw. When it is desired to utilise the quick power traverse, this motion can be de-clutched from the worm shaft by the horizontal lever shown. For slow movement or adjustment by hand the worm wheel is unclamped, and the worm shaft can be operated by the capstan hand wheel shown. We are informed that the machine shown has taken a cut of 8in. by ⅜in. deep at 2in. per minute, using a cutter 5in. in diameter. The table feeds range from 1in. to 3¼in. per minute, four rates being provided, and the spindle speeds are 20, 25, 32, and 40 revolutions per minute. In the view of the machine, with the cross slide and outer support removed, a 6in. facing cutter head is shown for vertical surface milling. The cutters are fixed in the spindle by a cone held in position by a screw, and positively driven by a driving notch in the end of the spindle embracing a similar flattened portion on the outer shank.

Fig. 41 represents a machine which has been designed by Kendall and Gent, Limited, specially for the purpose of milling the various flat facings on locomotive cylinders. On some engines these are placed at an angle vertically with the frame, and have valve chests with faces inclined to the bore of the cylinder as well as out of the centre. It will be understood that the setting of these castings to the correct angle for milling or planing is a matter of some delicacy. On the machine shown the various facings can all be dealt with at one setting of the casting, the necessary degree of inclination being readily attained by the provision of a special table—seen in Fig. 41, and in detail in Fig. 38. This table can be tilted to any angle up to 15 deg., and can swivel through a complete circle. The machine has a massive bed, 8ft. 6½in. wide by 7ft. long, provided with T grooves on its upper surface for securing the tilting table. At one end of this bed is secured a slide bed on which the main upright can move in a direction at right angles to the machine, the length of traverse allowed being 5ft. The upright is of substantial design, with a wide bearing on the bed, and is capable of being traversed by means of a nut working on a fixed screw. A rotating shaft in the bed driven by an electric motor through a change gear box transmits power by means of a pair of mitre wheels and a vertical shaft to the saddle carried on the upright. This saddle contains the gearing for imparting motion to the milling and boring spindle. This is of steel, and is 4in. diameter. It is supported in a cast iron sleeve carried in two adjustable bearings on the saddle, and is sufficiently rigid to carry a 6in. facing cutter head at its extremity, and a foot or more out of its bearing when cutting ¼in. deep in cast iron and at 1in. a minute feed without undue chatter or vibration. Milling feeds are provided in both directions, as well as a longitudinal advance to the spindle for boring, all movements being controlled from the saddle. The tilting and swivelling table, of which a detail drawing is given in Fig. 38, has an upper surface 5ft. square, and is grooved for the purpose of cramping work. It is provided with two fully indexed complete swivels, which can be locked in any position, the lower one being operated by worm and wheel and cross handle, and the upper one being merely pulled round by hand. The hinge forming the tilting adjustment is clearly shown in the detail drawing, the adjustment being performed by means of a worm gearing into a toothed segment formed on the tilting portion of the table. The table is moved along the bed by rack and pinion. The principal dimensions of the machine are:—Diameter of spindle, 4in; hand and self-acting feed of spindle, longitudinally, 3ft.; transverse adjustment of spindle, 5ft.; maximum height of spindle above table, 3ft. 6in.; minimum height of spindle above table, 6in.; boring feeds in revolutions per inch, 101, 66, 44, 30, 20, and 13; milling feeds, inches per minute, 1in., 2⅛in., and 4in.; there are twenty changes of spindle speeds varying between 8·6 and 66 revolutions per minute.

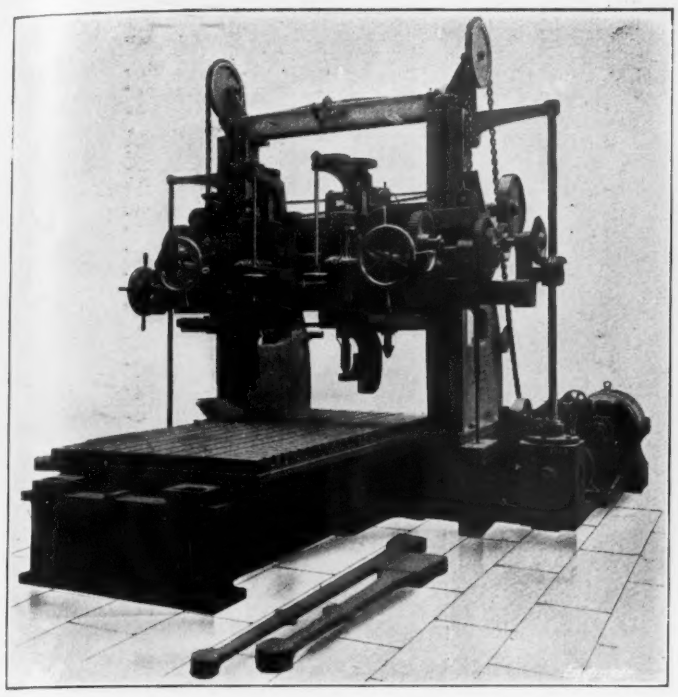


Fig. 44—DOUBLE SPINDLE PROFILE MILLING MACHINE—MUIR & CO., LTD.

A large four-spindle plano-milling machine, by Kendall and Gent, Ltd., is shown in Fig. 45. It is capable of dealing with work up to 13ft. long by 8ft. 2½in. wide and 6ft. 6in. high. The bed is of massive design, boxed in over the upper surface, and is provided with flat square-edged ways, to which is gibbed the work-table. The latter has T grooves and sud troughs connected to side channels with a sump, from which a small rotary pump returns the suds to the tool. The uprights are bolted to facings on the bed, and follow somewhat planing machine practice. In addition they are strengthened at right angles to their depth by box section side wings, to resist side pressure when using large cutters on the two spindles on the cross slide. The latter is of deep box section 15ft. 8in. long. It is moved up and down by power, and can be securely locked in any position. Motion is derived from a belt-driven cone with five speeds, the belt being 6in. wide. The four spindles are driven by mitre gearing, and each can be started or stopped independently. The two saddles on the cross slide have independent variable power feeds in either direction, with hand adjustment. The saddles on the uprights carrying the horizontal spindles have also independent variable feed motions along the upright in either direction, and are capable of hand adjustment, either of these motions being under control from either side of the machine. The same applies to the quick power traverse motion to the table; this is operated by means of the diagonal levers shown, which are provided on both sides of the machine. The table feeds are ten in number, and range from 1in. to 8in. per minute, the feeds of the saddles and spindles being the same. The quick power traverse to the table is independent of the rate of feed being employed, and is fixed at 6ft. per minute.

Milling machines have always formed a strong feature at the works of William Muir and Co., Limited, Manchester. This firm has recently introduced an improved machine for roughing out motor car engine cranks by means of milling cutters. Figs. 42 and 46 show the design of the machine very clearly. The blanks, having been previously machined on their flats, are placed between the end steadies and pass through the jaws of the gripping vices, which grip the cheeks of the crank webs. The cutter, of special design, automatically travels towards the blank until it reaches the correct diameter of the crank pin, and at this point is stopped by a special arrangement. A conveniently placed lever then causes the rotary motion of the gripping vices, which carry the crank pin with them in front of the cutter. When the pin has been roughed down to its proper diameter the upper jaws of the vice are "slacked off," and the table which carries the end stays, and the crank shaft, is caused to travel along until the next pin is brought into position. The vice is then re-locked, and a similar operation to the above repeated. The change from pin to pin is quickly performed, and the correct spacing is obtained by dead length gauges, which are inserted between the end of the table and a micrometer stop. In this manner accuracy in spacing is obtained without the necessity of marking out the cranks. It should be pointed out that the hand-wheel controlling the in-traverse of the cutter acts also as a micrometer, so that in milling a batch of crank shafts uniformity of diameter of the pins is assured. The machine is designed to deal with either four or six-throw crank shafts. The pins of a six-throw crank can be cut in 4½ hours, this time including the time lost in changing from pin to pin. The cutter employed on this machine is of special design, being of the expanding type to accommodate varying lengths of crank pins, and also to allow for wear. The cutting edges of the tools are made with corners accurately rounded off to the desired radius, and are arranged so as to leave a clearance shoulder on the pin next the webs to meet the requirements of the grinding tool by which the crank pins are finished. Messrs. Muir have recently designed a special milling machine for cutting grooves in turbine blading. The machine—Fig. 43—is portable and driven by an electric motor, and is shown cutting dovetail grooves in a cylinder. It is designed to cramp to the flanges of the cylinders wherever required, and will accommodate itself to all sizes of Parsons' turbines. The cutters of special dovetail form are carried in the spindle and traverse automatically to the required depth, the spacing from stop to stop being gauged by a vernier and a rule along the cross slide. The chief features of this simple tool will be easily understood by examination of the illustration. It may be mentioned that the makers are licensed by Messrs. Parsons to supply these machines to the latter firm's licensees and to the British Admiralty. A type of machine with which Messrs. Muir's name has become familiar is shown in Fig. 44. It is an electrically-operated double-spindle profile milling machine, which is largely employed in railway works for operating on coupling and connecting-rods.

Fig. 50 represents a vertical tool which has found favour amongst motor car manufacturers for treating engine frames, crank cases, and gear-boxes. It is built by Geo. Richards and Co., Limited, Broadheath, near

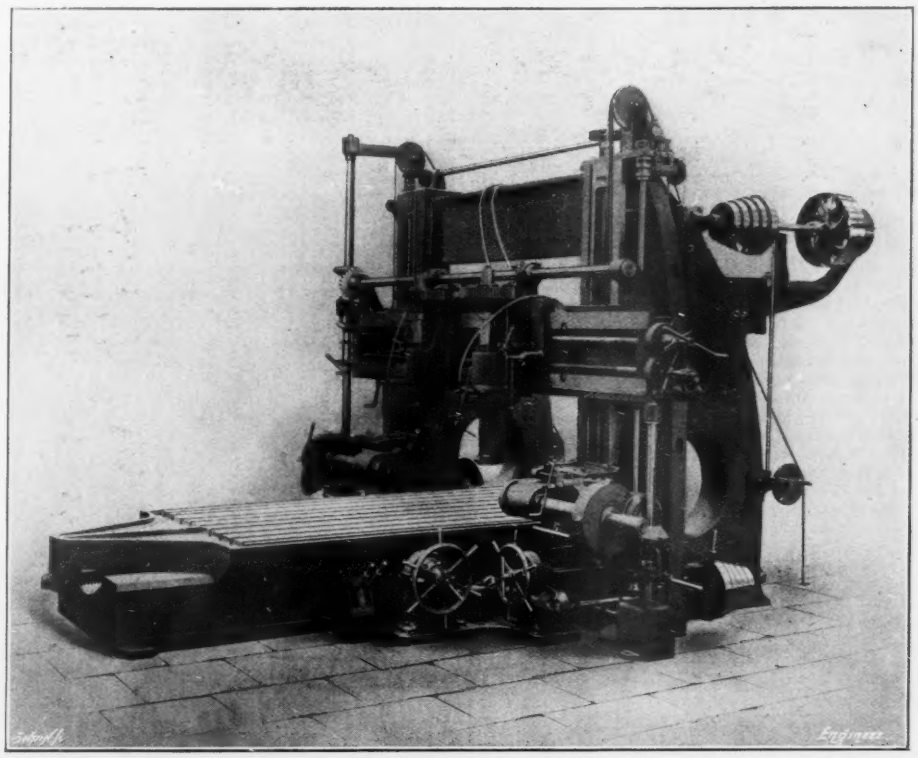


Fig. 45—FOUR SPINDLE MILLING MACHINE—KENDALL & GENT, LTD.

Manchester, and is of pleasing design. The special features of the machine are the duplex arrangement for driving the spindle, sectional drawings of which are given in Fig. 47, and the wide range of movement which can be given to the table in both directions. The duplex system of driving enables the spindle to be rotated at speeds most suitable to the material being treated and to the size of cutter employed. The gear shown provides a range of twelve speeds, and the spindle is driven alternately as desired by a worm wheel for slow spindle speeds and by

spiral gears for quick speeds, the changes being made instantly by means of the lever shown. The machine is built in two sizes. That shown in Fig. 50 has uprights 4ft. 4in. apart. The cross arm carrying the spindle has a vertical adjustment by hand of 26in. above the table, and

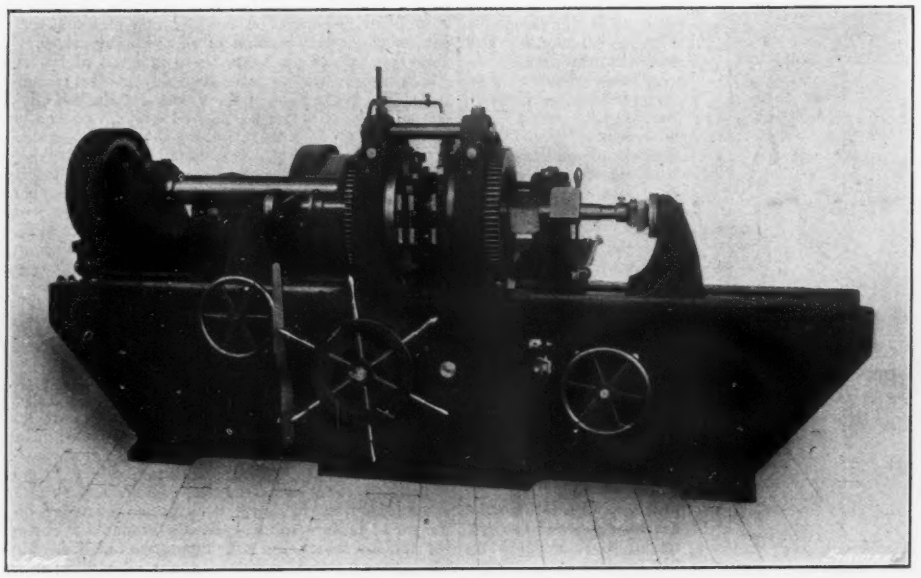


Fig. 46—CRANK SHAFT MILLING MACHINE—WILLIAM MUIR & CO., LTD.

the spindle has a fine adjustment of ¼in. independent of the cross arm for putting on the feed. Although a rectangular table, 42in. by 24in., is shown, a circular table, 24in. diameter, with self-acting circular feed, can be fitted. The table has a movement of 8ft. in one direction and of 20in. in the other. The countershaft has fast and loose pulleys 12in. in diameter for a 3in. belt. A positive feed motion is provided, all the gearing being enclosed in a dust-proof box filled with oil. The base of the machine forms a reservoir for water, which is supplied to the

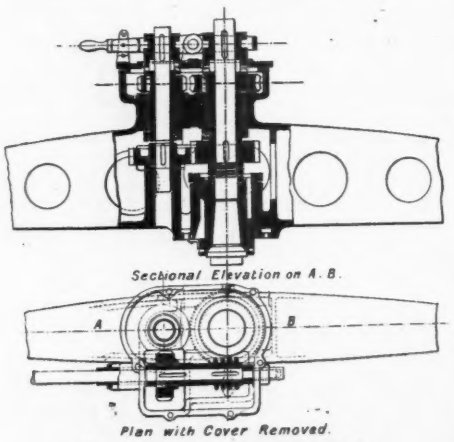


Fig. 47—SPINDLE DRIVE—RICHARDS

cutting tool by means of a centrifugal pump fitted to the machine.

Fig. 51 shows an automatic milling machine built by Smith and Coventry, Limited, Gresley Ironworks, Manchester. The spindle pulley is driven by a four-speed cone pulley, mitre gearing, vertical shaft, and horizontal belt. The drive is direct for the single speeds, but for double gear speeds gearing is provided which gives a ratio of 8 to 1 between the pulley and the spindle. The cross slide is designed to rise and fall by power. The spindle is carried in a vertical slide on a saddle, and the lower bearing is conical, with adjustment to take up the wear. The bearing rises and falls with the spindle, keeping the latter rigid in all positions. The saddle has a self-acting positive feed in both directions, and can also be traversed by hand when desired. The table is of strong section, is driven by a screw, and has a self-acting traverse in both directions, with automatic knock-off motion. Both the saddle and table speeds are variable, and are instantly changed by means of a hand lever in front of the gear-box, which is placed conveniently for the operator. Fig. 48 shows the arrangement of the change-speed gears.

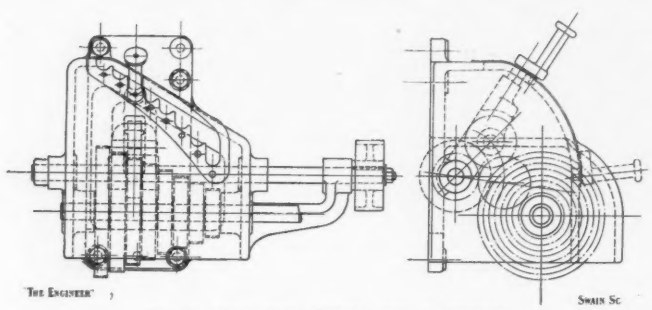


Fig. 48—GEAR BOX—SMITH AND COVENTRY

A self-acting circular table, removable at will, is provided. The saddle of the machine can be instantly disconnected from the feed screw and coupled up to a copying motion to enable cams to be milled. The cutter lubricant is supplied continuously by a pump and a constant flow between the reservoir and the tool by suitable channels. Fig. 52 represents an end and front elevation of a motor-driven high-speed vertical milling machine made by Smith and Coventry. The illustrations show very clearly the method of driving and the various motions.

The horizontal milling machine shown in Fig. 54 has been specially designed by James Spencer and Co., Hollinwood, for general milling of flat and shaped work. The bed is of box section, with hollow box stays connecting the two slides, the tops of which form flat slides for the table to work upon. The tables are deep and well ribbed, with a drain trough on each side, and a long tray at each end to catch the lubricant, which drains into a trough along one side leading to a tank in the centre of the bed. The table is gibbed to the bed by square strips, with adjustment to take up wear, and is traversed along the bed by a square-threaded screw, carried by a bracket underneath each end of the table. At the centre of the bed is fitted a pedestal having a revolving gun-metal nut through which the screw works. The self-acting motion to the table has eight changes of feed towards the cutter by means of a four-speed cone in conjunction with a quick change of gear. A quick movement is provided for the table worked by power in both directions. The table can also be traversed by hand when desired. An automatic disengaging nut motion is provided to stop the traverse of the table in either direction and at any point. The uprights are of box section, securely tongued and bolted to the bed, and connected at the top by a cross stay. The cross slide is well braced and balanced, and so arranged that it can be raised or lowered by hand or power to adjust the cutters to their work. A saddle is fitted to the purchase spur gearing from the four-speed cone. The cross slide is also fitted with two brackets for supporting the mandril; the intermediate bracket has a parallel hole, and the other has an adjustable conical bush for supporting the outer end of the mandril. The length of the table is 10ft. and the space between the uprights 3ft. 6in. The

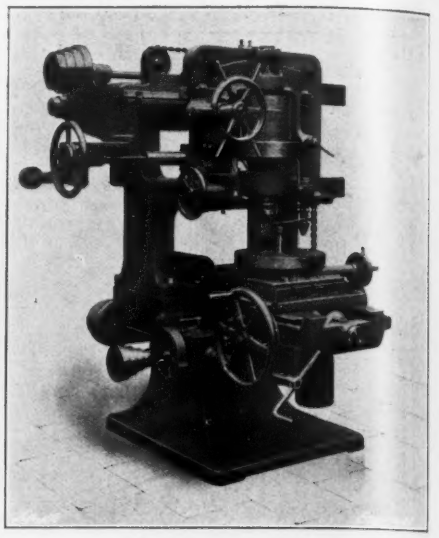


Fig. 49—MILLING AND PROFILING MACHINE

spindle is 5in. diameter, and the largest admissible cutter diameter is 12in.

A vertical milling and profiling machine by the same makers is shown in Fig. 49. It is intended for milling around the edges of regular or irregular shaped articles, as well as for surface milling and general work within its capacity. The combined movements of the spindle and table will produce either straight, curved, circular, or irregular forms. The main body casting is in box form, with tank and strainer to catch the cutter lubricant. The uprights and cross slide form one casting securely fixed to the body. The vertical slide has a screw adjustment, and is fitted with case-hardened steel spindle running in conical gun-metal bearings, with adjustments to compensate for wear. The horizontal slide runs freely on rollers, and is fitted with a self-acting screw feed, variable and reversible, for general work. A quick traverse motion by rack and pinion is also provided, with balance weight, for use when engaged upon profiling or former work. The spindle can be run either single gear or through internal spur gearing, with four-speed driving cone giving eight changes of speed. The table measures 30in. by 16in., and has a traverse of 30in. It has a variable self-acting motion in either direction, with quick hand traverse and fine adjustment by worm and worm wheel. The vertical, transverse, and table slides are fitted with indexed steel rules for accurate adjustment. The machine will admit work 24in. wide by 10in. high, and the spindle traverse is 16in. horizontally and 4½in. vertically.

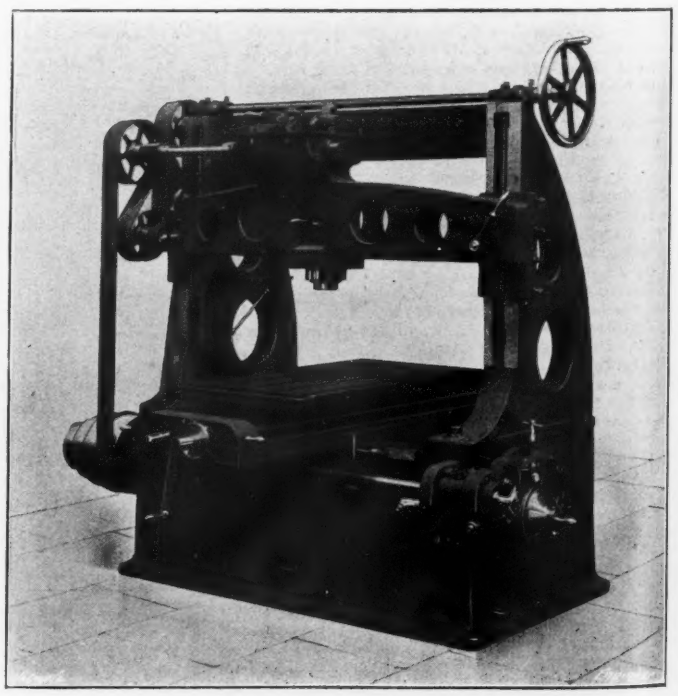


Fig. 50—VERTICAL MILLING MACHINE—GEO. RICHARDS & CO., LTD.

vees on the cross slide carrying the main bearing for the spindle, which is conical and adjustable to take up wear at the end nearest the cutter. The parallel part of the spindle is carried on a cast iron sleeve, which is driven by belt from the cone pulley shaft, or through double

Fig. 53 represents a machine with vertical and horizontal spindles which can be worked together or separately. It will deal with objects up to 12ft. long. The saddle has both hand and self-acting traverses in both directions through a range of 3ft. by steel screw working

in a gun-metal disengaging nut. For profiling work the saddle can also be traversed by a rack and pinion. Balance weights and chains are provided for use when profiling from a former fixed on the table. An adjustable profiling guide spindle is also fitted on the saddle. The bed, table, and means for securing the uprights are similar to those in the machine illustrated in Fig. 54. The table motions are also obtained in the same manner. The 4in. vertical steel spindle is carried in a second saddle, and the bottom of the vertical slide has an adjustable swivelling mandril stay.

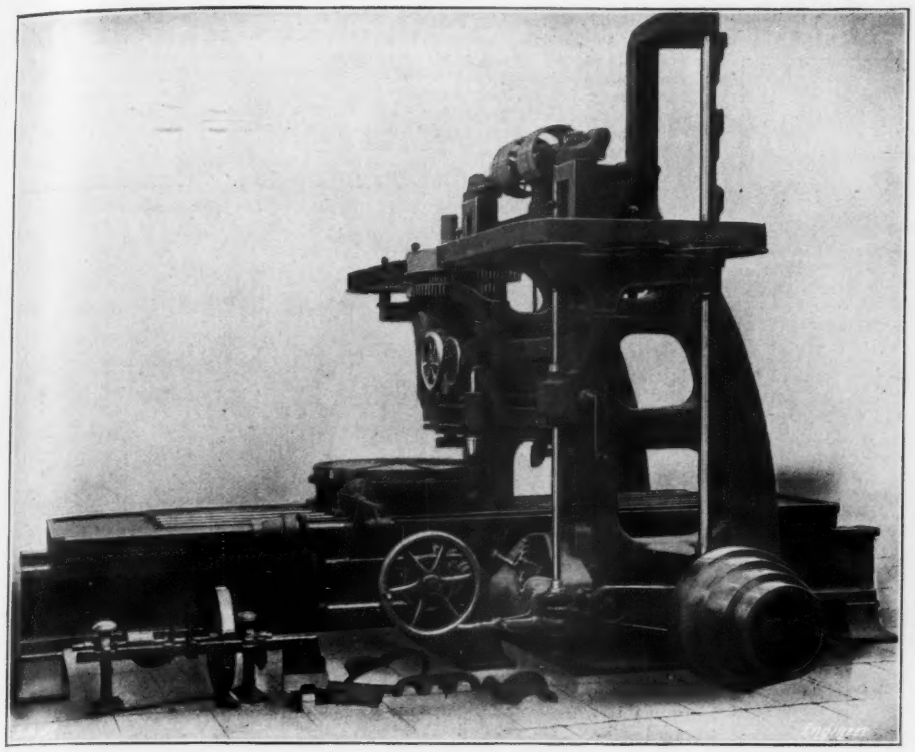


Fig. 51—VERTICAL MILLING MACHINE—SMITH & COVENTRY, LTD.

Several well-designed machines constructed by Tangyes Limited, of Birmingham, are the subjects of illustration. The horizontal machine shown by Fig. 60 is interesting on account of the bent belt drive to the spindle. The headstock is treble-geared, and the machine is suitable for heavy cuts, but the main object of the gearing is to provide appropriate speeds for edge and face milling. For the latter the whole gear, with a ratio of 41 to 1, is employed, whilst the second gear, 25 to 1, or the first, 3 to 1, is used for the former. The cone pulley has four speeds, so that with the three ratios twelve changes in all are obtainable. The spindle is of forged steel, is 7in. diameter at the front end, and runs in conical bearings; on its front end a disc to take the facing block is forged, and hardened steel washers with adjusting nuts take the end thrust. The spindle head has vertical adjustment on a vertical column, and the column has also a short horizontal movement for end adjustment, hence the wide belt pulley. The feeds are driven from the main cone shaft, and are varied by the levers seen at the front of the machine. Eight changes for each speed are obtainable. The table is fed along by a revolving screw of large diameter, and an automatic trip motion is fitted. The machine is manipulated entirely from in front. When it is desired to use a face cutter, the outboard support and the steady bar are removed, as shown in Fig. 57. The length and traverse of the table is 72in., the table is 29½in. wide, and the distance from its face to the spindle centre is 27in., and of the spindle from the arm 7½in.

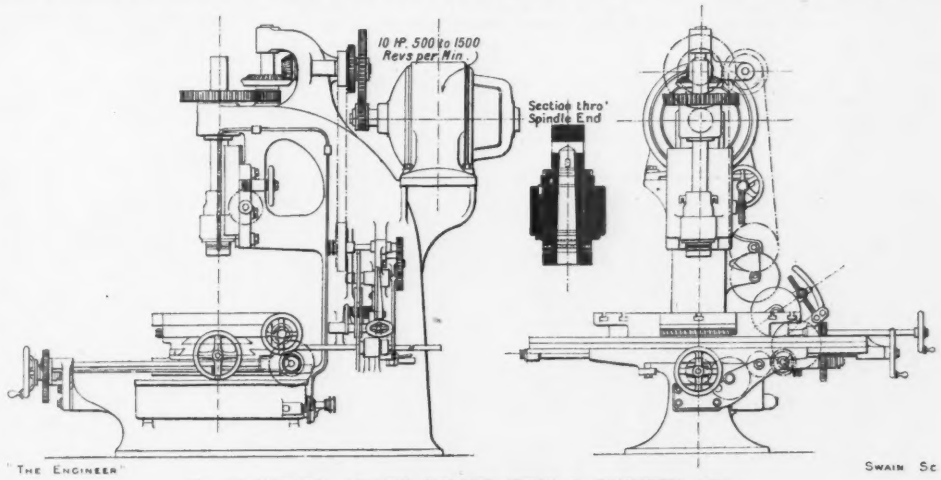


Fig. 52—VERTICAL MILLING MACHINE—SMITH & COVENTRY, LTD.

Two vertical machines by Tangyes, Limited, are shown in Figs. 55 and 56. The first of these is a general purpose machine designed especially for use with high-speed steel cutters; the main castings have therefore been made of very stiff box section. The spindle is driven by a right-angle belt from a three-step cone, which with back gear at the top of the machine gives it twelve changes of speed with a two-speed countershaft. These speeds rise in geometrical progression from 12 to 353 revolutions per minute. The bottom bearing is conical, and runs in a gun-metal bush, provision for wear being made by means of hardened steel thrust washers and lock nuts. The spindle has a hand or automatic traverse of 8in. in lieu of upward feed of the table, thus economising the power absorbed in lifting the heavy table with the work. The table has, however, vertical adjustment or feed by hand through the medium of a gun-metal nut and screw, the friction being taken on a ball bearing. The spindle slide, which is balanced, can be brought down to a dead stop, and automatic stops to the table in both directions are fitted. The table has machined tee slots, and can, as shown in the illustration, carry a circular table when required. Troughs for lubricant are provided, and a tank and pump are fitted at the back of the frame. The guide pulleys are on a swivel to take up any stretch of the belt. The feed is driven from an independent two-speed countershaft through a gear-box, and thirty-two changes in all are obtainable. The arrangement of the gear in this box is shown in Fig. 59. The two-speed shaft is provided with two pulleys, to which either of the wheels *a* or *b* may be belted. The shaft A to which they are keyed drives a second shaft B through two pairs of wheels engaged by claw clutches. Shaft B has two wheels keyed on it, and a pinion cut solid on the shaft. Shaft C has two wheels with a clutch between them, also the four loose wheels which the sliding key operates. Shaft D has the four wheels to gear with the sliding key wheels, and also carries the reversing mitres which have a clutch between them. The first four changes of feed are obtained through the four wheels and sliding key. The succeeding feeds are obtained by changing the clutches on shafts A and C.

The method of working the sliding key is as follows:—On the bottom end of the hand-wheel shaft a small pinion is keyed. This pinion gears into a short rack cut on a separate sliding shaft. The lever nearest the belt pulleys is keyed to this sliding shaft, and is made forked at the outer end to slip between two solid collars turned on the rod which pulls the sliding key. The spring plunger works in the four holes which are countersunk in the rim of the hand wheel. The reason holes 1 and 4 are close together is as follows:—The travel of the sliding key in passing through the four wheels is 5½in., therefore the sliding shaft and forked lever have to be moved this distance in something *less* than one revolution of the hand wheel. The pitch diameter of the rack pinion on the hand-wheel shaft is 1¾in., and the circumference is practically 5½in., therefore in slightly less than one revolution the key has been passed from the first to the fourth of the wheels.

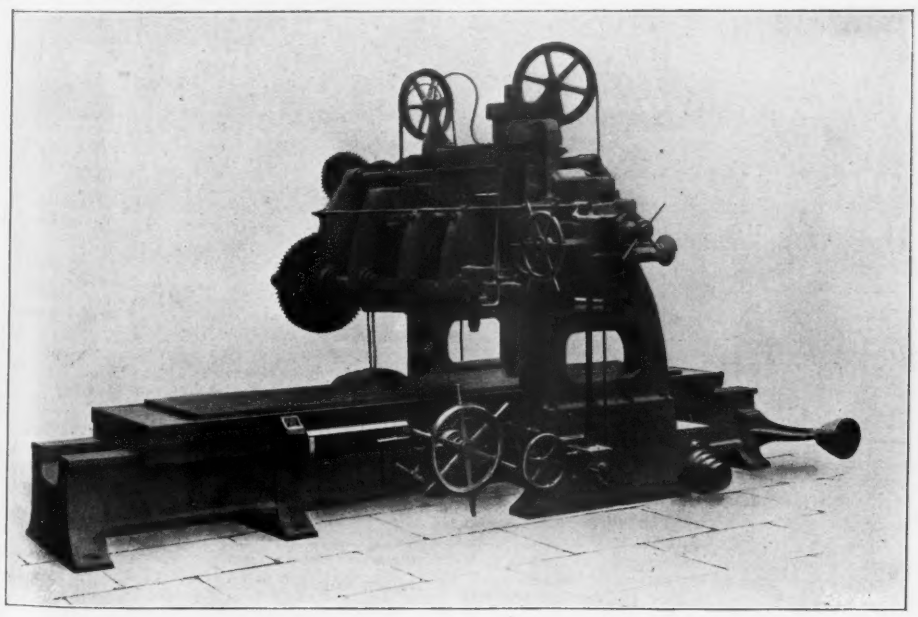


Fig. 53—HORIZONTAL AND VERTICAL MACHINE—J. SPENCER & CO.

Fig. 56 shows a machine by Tangyes Limited originally designed for milling out the ports of steam cylinders, and it will admit cylinders of the usual pattern up to 24in.; but it is also suitable for a variety of work. The machine is driven from a two-speed countershaft through cone pulleys, giving a total of sixteen speeds to the spindle. The spindle is counterbalanced, and is carried in a sliding head which can be adjusted up and down the column by hand, so that the spindle may be supported close to the work. The back gear is carried at the top of the frame, and is operated by handles placed conveniently at the side of the machine. The table has automatic longitudinal cross traverse, and can be also operated by hand. It has a circular table sunk in it for use when dealing with circular work. Reversing motion for the feeds is provided. The spindle has also a hand adjustment of 6in., and a steady bracket for using with long cutters is provided.

A large face milling machine by the same makers with a cutter block, 46in. diameter, for milling either by face or edge cutters, large surfaces such as columns, girders, halves of fly-wheels, keyways in large shafts, &c., is shown by Fig. 58. It is of exceptional strength and power, so that such work can be done quickly; on large cast iron faces traverses up to 6in. per minute can easily be taken. The spindle is of steel, 12in. diameter in the bearings, and carries a large face-plate with a set of tools, each separately adjustable by set screws; this face-plate has an internal ring on the back, and is driven through either single or treble gearing. The headstock has cross

adjustment by hand of 6in., and vertical power or hand adjustment on gibbed slides by screw and worm gear, the vertical movement being on an angular slide to ensure rigidity; the slides can all be bolted tight when the machine is at work. The headstock base is bolted and keyed to the bed, which carries a table with planed T slots in the top; this table has slow-feed and quick-power movement in either direction by screw, driven from the countershaft by cone pulleys and change

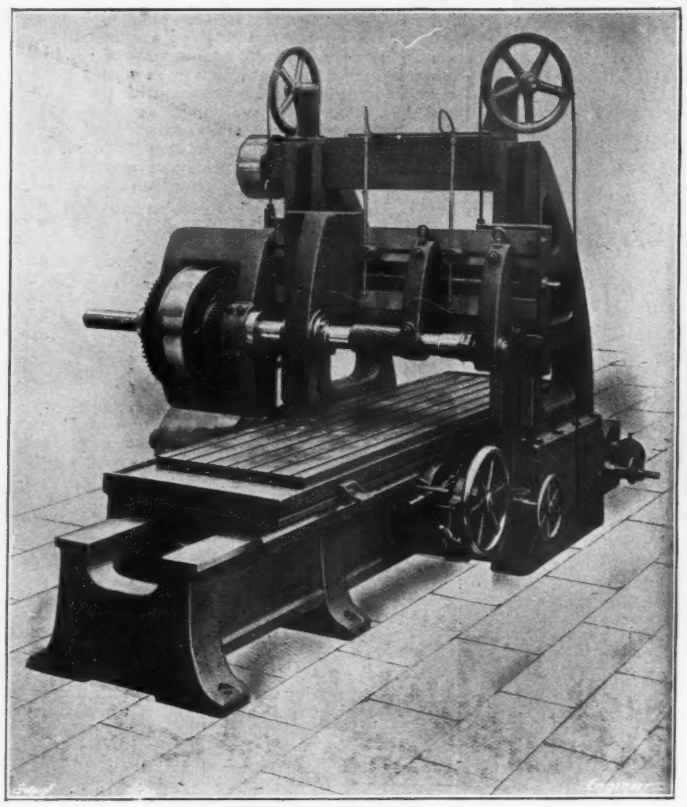


Fig. 54—PLANER TYPE MACHINE—J. SPENCER & CO.

Figs. 69 and 70. The vertical machine is driven by a right-angle belt in the usual way, the drive being taken from a pulley keyed to a three-step cone at the back of the upright. The back gear is at the top of the machine. The feeds are driven independently by a two-speed pulley from the countershaft, and it is so arranged that when the driving belt is thrown off the feed belt is also thrown off, so that there is no fear of the feed continuing after the rotation of the mill has ceased. The change feed box, near the base of the machine, gives eight changes, operated by three levers, of which one reverses on any speed, and another gives a quick change from roughing to finishing. The gear box is practically an oil well, and the wheels are therefore copiously lubricated. It is complete in itself, and can be removed by withdrawing four bolts. There are knock-out motions for all feeds, and they are actuated by drop-out worms.

The spindle is 2in. diameter on the driving part, and 3in. in the largest part of the lower neck. It is hardened and ground, and runs in gun-metal bearings, of which it will be observed there are two on the headstock, instead of one, as is the ordinary practice. The thrust is taken on hard steel collars. The headstock has a vertical adjustment of 3½in. by means of rack, worm, and wheel, the latter being divided to $\frac{1}{1000}$in. A stop for depth with very fine indexed adjustment is provided. The spindle runs in a fixed bush on which the back gears run.

The knee bracket is of complete box form, and has an elongated vertical slide; it is raised and lowered by a telescopic screw. The various hand wheels for operating the slides are provided with indexes, and, as already said, have knock-out motions for the automatic feeds.

The countershaft runs at two speeds, 230 and 525 revolutions per minute, and twelve changes of spindle speed, varying regularly between 39 and 840 revolutions per minute, are obtainable. The sixteen table feeds run from ·45in. to 6in. per minute.

The small plain milling machine—Fig. 61—by the same makers, is driven by a three-step cone with back gearing. The feed is taken from a pulley on the end of the main spindle; this pulley drives a three-step cone on a swinging arm, which is just visible in the illustration. The cone, in its turn, drives the step pulleys on the feed shaft. This arrangement is introduced to permit the knee bracket to be raised or lowered without affecting the tension of the feed belts. The design is so simple that the machine calls for but little description.

Another machine built by the same makers is the little Lincoln type miller, shown by Fig. 70. It is one of a series of three sizes, all similar in design. The smallest has a table, 3ft. by 9½in.; the second a table 3ft. 6in. by 11½in.; this machine is illustrated; and the largest a table 4ft. 7in. long by 12in. wide. The bed and headstock vertical are cast in one piece, which is firmly bolted to a pedestal cupboard. The spindle runs in parallel split bearings in the headstock, and the outer mandril end is carried by a split taper bush with a parallel hole. The spindle is driven by a three-step cone through spur gearing. The feeds are driven from the first motion shaft under a three-speed cone, and thence by worm and wheel. The worm may be dropped automatically or by hand. Cross feed is effected by hand only.

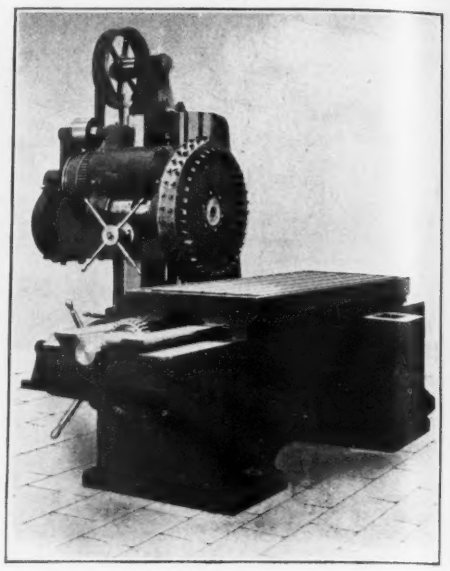
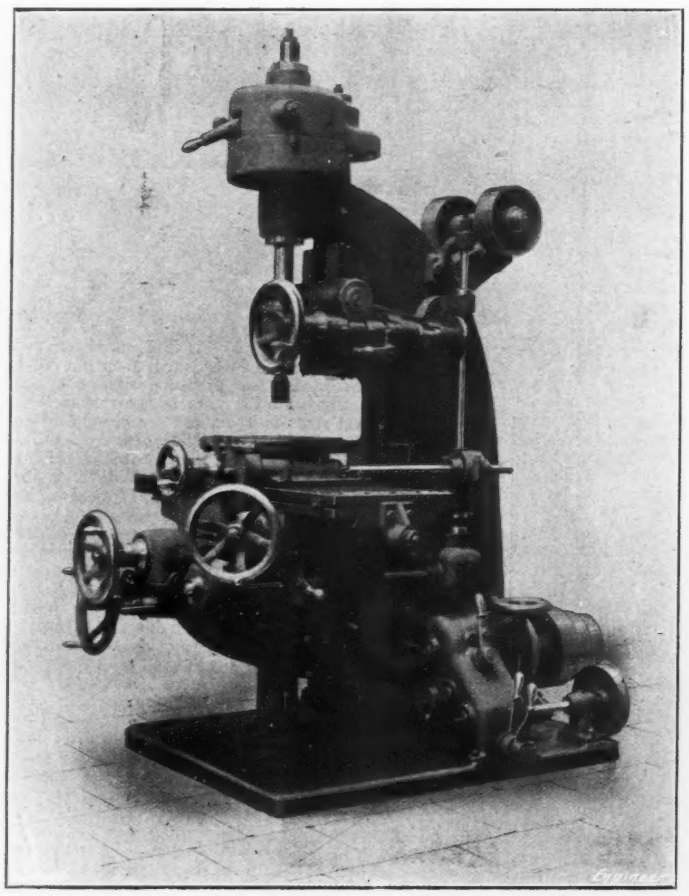
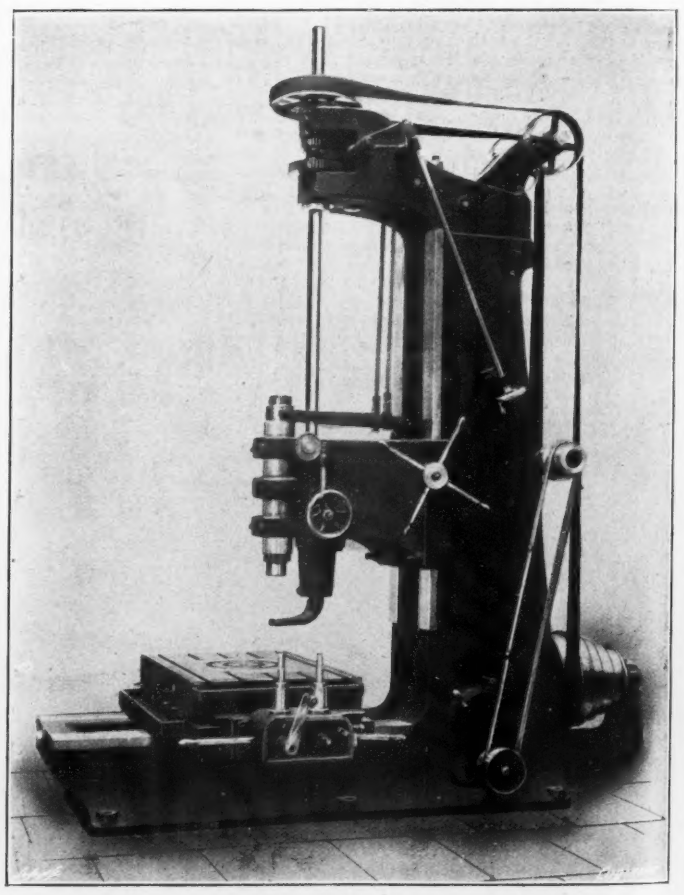


Fig. 57—FACE MILLING MACHINE—TANGYES LIMITED





Figs. 55 and 56—VERTICAL MILLING MACHINES—TANGYES LIMITED

wheels; all the traverse movements are started, stopped, and reversed by levers placed close to the operator. The table is 20ft. long, with a self-acting feed motion the full length.

Three of the latest designs of milling machines, made by H. W. Ward and Co., of Birmingham, are shown in

We have in the introduction referred to profile milling

machines, which include so large a variety of tools that it would be impossible to deal with them anything like fully. It seems, however, desirable to give at any rate a few examples, and we have, therefore, selected a few designs for description. Webster and Bennett, Limited, of Coventry, have made a special feature of machines of this class used in the production of textile machinery, and of various parts of motor cars and cycles, and from their numerous designs we have selected the two machines illustrated in Figs. 62 to 67.

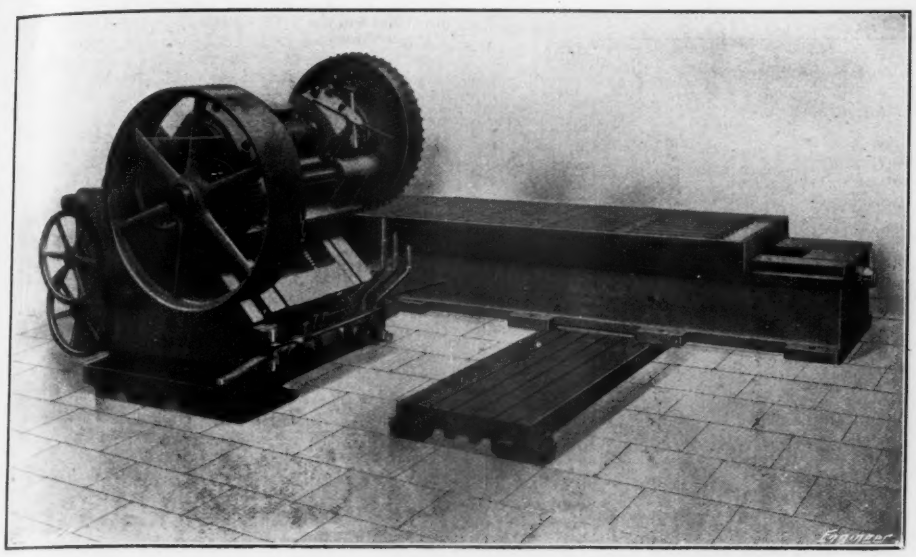


Fig. 58—FACE MILLING MACHINE—TANGYES LIMITED

Figs. 62 and 67 show a profile miller arranged for the generation of motor car cam shafts direct from the solid. The shafts are first prepared in the lathe, which turns the whole of the cylindrical part, leaving a number of discs which have to be reduced to the desired form by the milling machine.

The blank cam shaft is passed through the hollow spindle R—Fig. 67—and gripped in the self-centering chuck S Behind the chuck are secured the former plates T T, which in this case are arranged to cope with a shaft having two different outlines of cams upon it. The cutter slide U moves to and fro on a knee slide V, and carries a copy roller to engage with either of the formers T T. The roller is pressed against the copy and the cutter against the work by an adjustable spiral spring carried in the knee slide. The hand wheel at the front operates a screw which controls the movement of the cutter slide during the first or roughing cut, and prevents the cutter digging too deeply into the work. During the second or finishing revolution of the work the cutter is governed solely by the former, and consequently the desired outline is produced. After a cam is finished the cutter slide is moved backwards by the same hand wheel, while the shaft is moved lengthwise and the next disc brought opposite the cutter.

The automatic feed motion which revolves the work against the cutter is driven from the cutter pulley shaft by belt through worm gears enclosed in oil baths. In the event of the cutter belt breaking the feed motion stops. Tension rollers W W are provided to keep the feed belt tight when the cutter slide moves to and fro. The feed is stopped and started by the friction clutch at the rear of the hollow spindle. The angular displacement of the cams relatively to each other is fixed by a division plate which occupies the place of a loose headstock, the end of the shaft being securely held in a collet. The use of the division plate ensures the different cams along the shaft being in correct relation to each other. The dividing head slides along the bed with the cam shaft and the dividing lever is released before the feed is started.

The machine is driven by a single pulley, and it can therefore be motor driven without alteration. It will be observed that by this arrangement of sliding the shaft through a hollow headstock the particular cam being operated upon is close to the chuck, and is therefore very well supported. The drive is fairly obvious from the drawing. The single big pulley is belted to the countershaft, and by means of the worm gear already referred to rotates the work spindle. This gives the circular feed, which is at the rate of one revolution in 2·81, 3·75, or 5 minutes. The cutter spindle is driven also by a belt, which passes over the pulley X on the big pulley shaft, and round the group of pulleys W W, W_1 W_2. The last two wheels are on the cross slide, and W_2 is geared to the cutter. This arrangement of belt permits of the slide being moved to and fro as required.

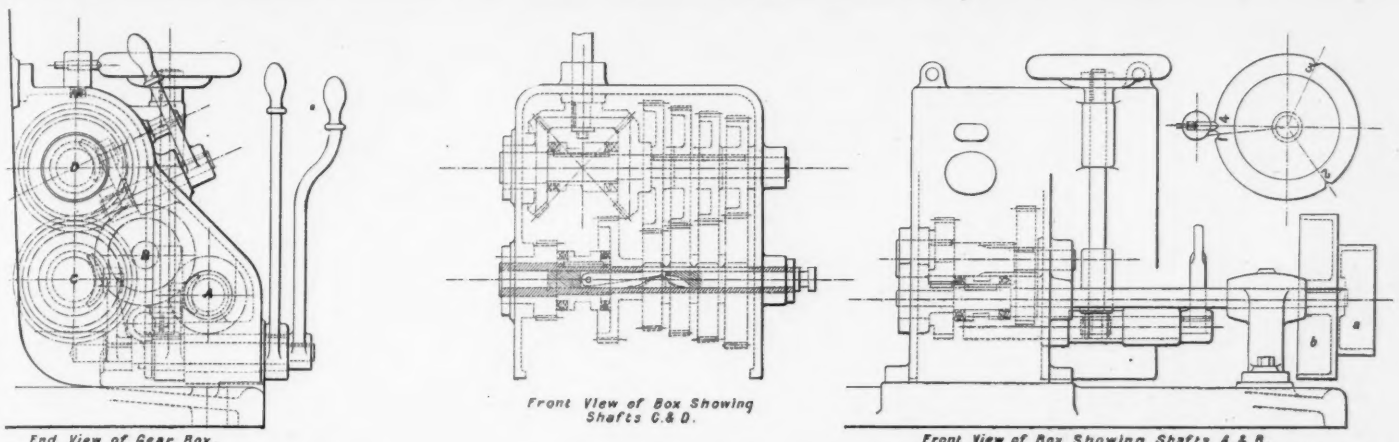


Fig 59—CHANGE FEED GEAR—TANGYES LIMITED

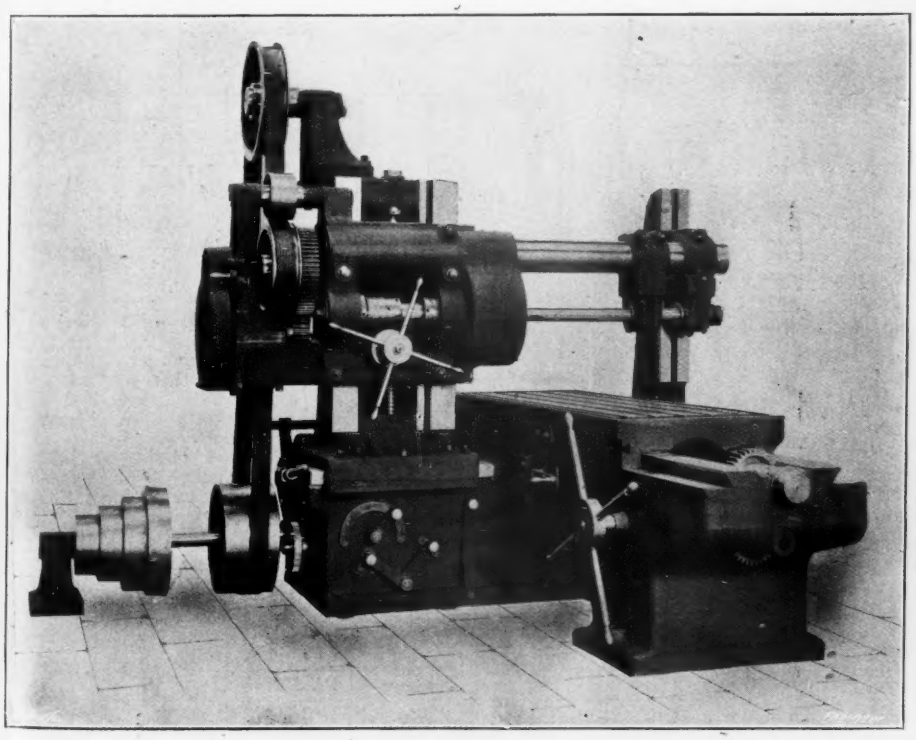


Fig. 60—HORIZONTAL MILLING MACHINE—TANGYES LIMITED

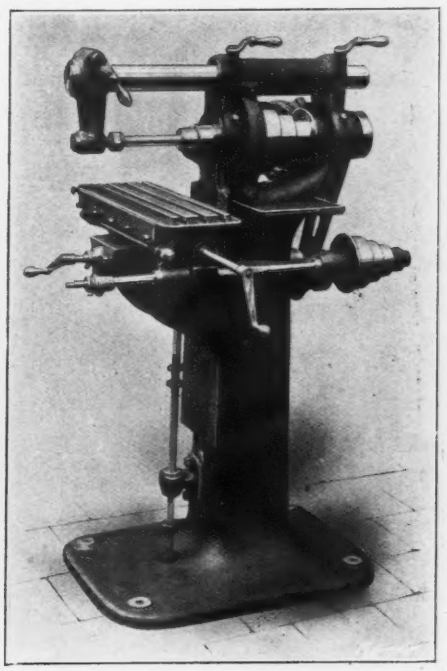


Fig. 61—SMALL MILLING MACHINE

The second machine, by Webster and Bennett, Limited,

which we illustrate, is a far more elaborate machine, but is a more generally useful tool, as it will cut all such parts as cams, glands, links, cycle and motor parts, squares, octagons, and so on. It consists of two similar

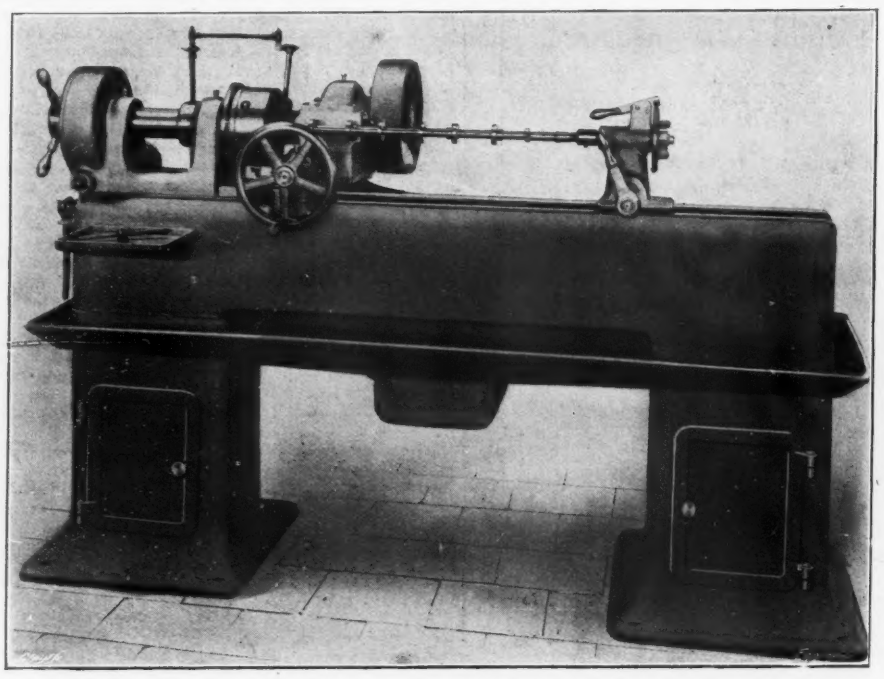
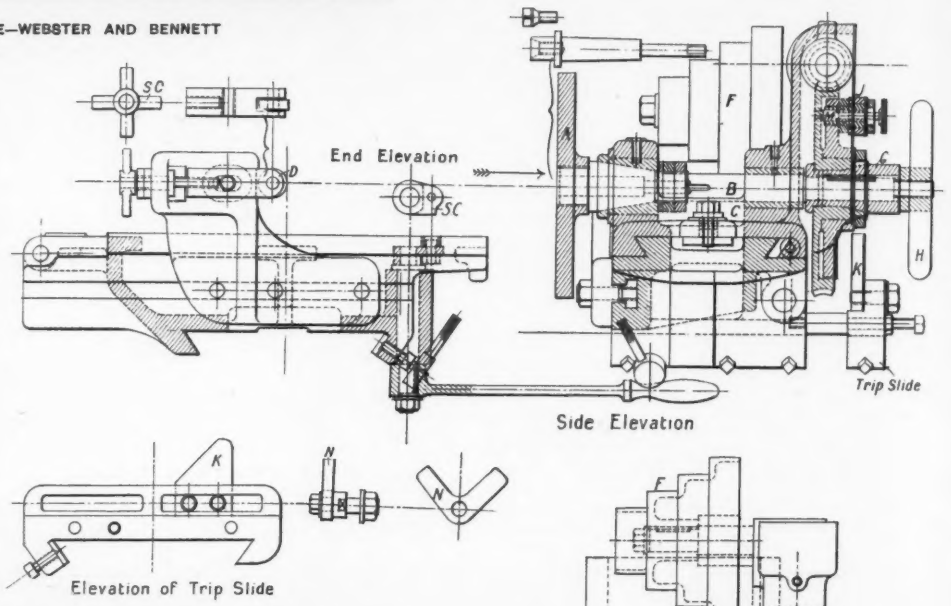


Fig. 62—CAM MILLING MACHINE—WEBSTER AND BENNETT

machines on one bed, and is therefore called duplex. In Fig. 64 a section of the headstock is given, and it will be seen that the spindle runs in conical bearings, and that the end thrust, set up by the spiral teeth of the cutter, is taken on a tail pin running in oil. In this machine, unlike that just described, it is this spindle that carries the cutter, and runs at a high speed, the work being mounted on the saddle illustrated by Fig. 65. In this drawing A is the former plate screwed on the spindle B. The work itself is chucked in front of the former plate A.

The slide C, carrying the former plate and its spindle, is, of course, controlled in its movement by the profile or outline of the former plate, which is held up to the copy roller D by weights suspended at the back of the machine. The feed motion is transmitted to the former plate by the worm gear, which is driven by the cone pulley F belted to the countershaft. The worm wheel is not keyed to the spindle, but operates through the medium of a friction cone G tightened by hand wheel H. When a very awkward shape is being milled, and the former A refuses to pass the roller D, this clutch slips, and the roller J engages with an inclined plate K, and assists the slide C forward until the obstruction is passed and the feed taken up again by the friction clutch. This relieving roller J is carried on a plate sleeved on the boss of the



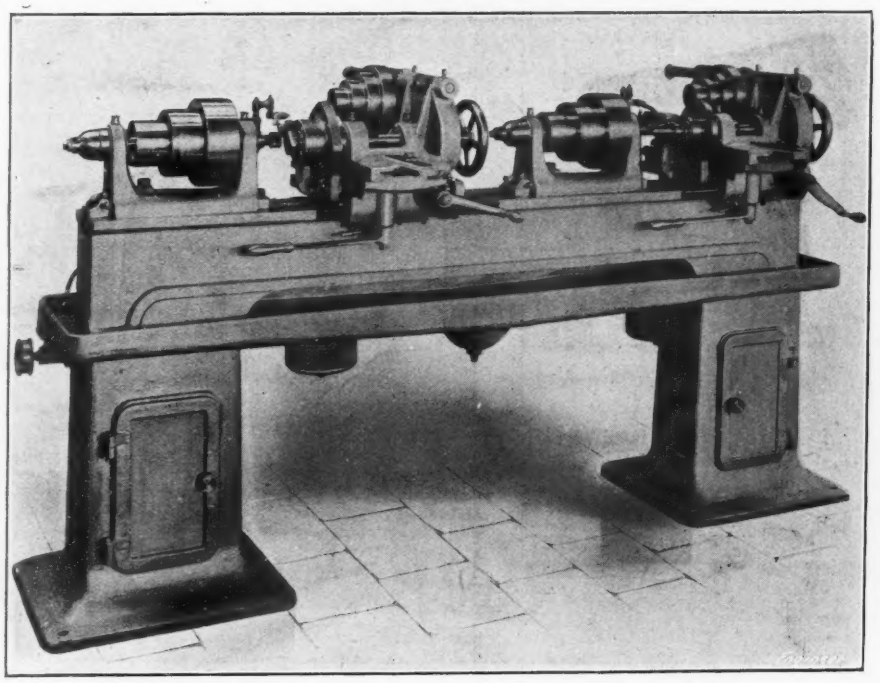


Fig. 63—DUPLEX CAM MILLING MACHINE—WEBSTER AND BENNETT

worm wheel, and is connected to it by a spring plunger M inside the roller stud. This spring plunger engages with one of a series of holes drilled in the worm wheel, which is substituted for the relieving plate K. At the conclusion of the first revolution of the feed the roller J throws the lever N over and passes on. On the conclusion of the second feed revolution the roller J engages with the left arm of the lever N, whilst the right arm has previously been thrown against a solid abutment. The result is that the lever N can move no further, the slide C is forced forward, the work being thus withdrawn from the cutter and the feed clutch disengaged. The lever N is thrown into its idle position by the operator before fixing the next piece. By this means a roughing and a finishing cut are taken on the work, and then the process is automatically stopped. It is claimed that this

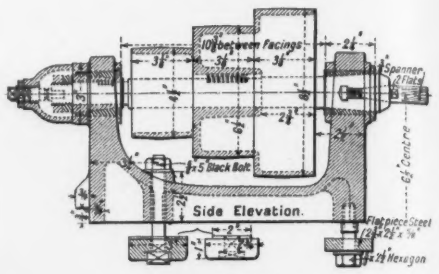


Fig 64—HEADSTOCK

ingenious arrangement permits of the production of such irregular shapes as could not be made without some device of the kind. Some examples of the time taken to perform work on these machines may be found of interest. A complete motor cam shaft with eight cams is produced from the previously turned work in 80 minutes, whilst a four-cam shaft with bevelled cams is under the same conditions turned out in 50 minutes. Pinion cams for motor cycles, and small cams for gas and oil engines, are made at the rate of fifteen per hour. Sprocket wheel centres for bicycles, star-shaped pieces with three points,

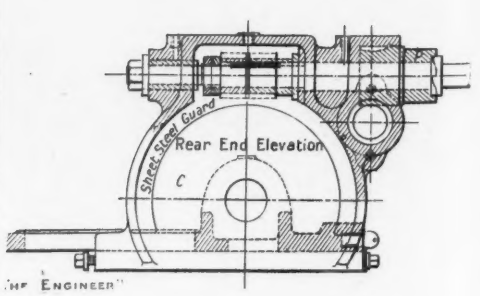


Fig. 65—DETAILS OF CAM MILLER

are milled all round at the rate of ten per hour, whilst twelve gun-metal glands for half-inch rods are machined in the same time. These few examples will give an idea

of the rapidity with which the machines operate, and the large variety of work to which they can be applied.

The simple and straightforward machine shown in Fig. 68, and made by G. Wilkinson and Sons, of Keighley, traverse 1ft. The maximum distance from the spindle to the table is 1ft. 4in.; the table measures 4ft. by 1ft. 4½in., and the cone diameters are 14⅞in., 12¾in., 10⅝in., by 3¼in. wide.

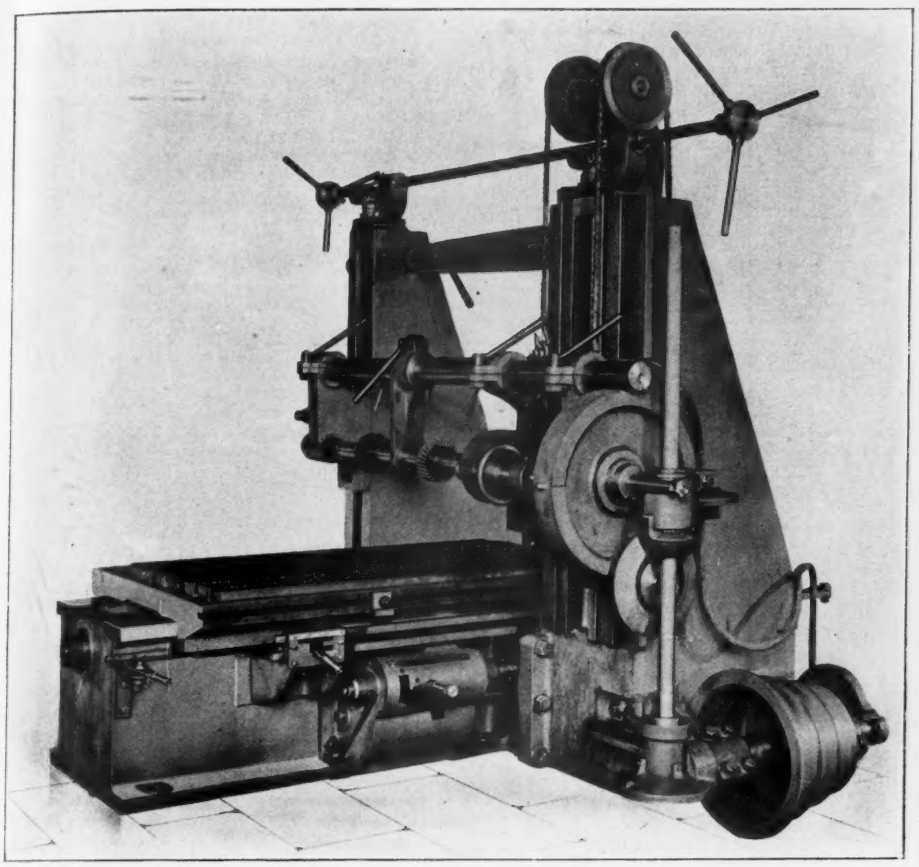
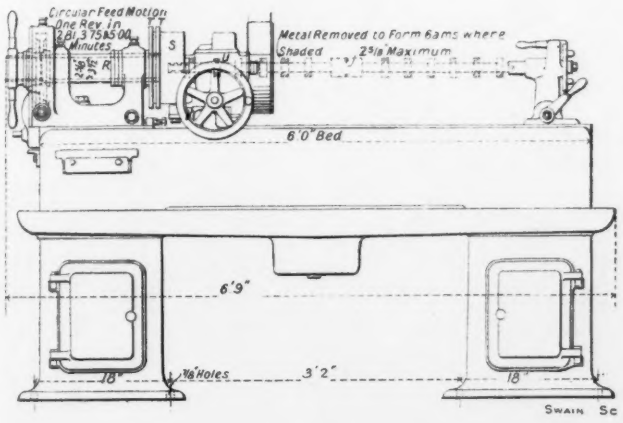


Fig. 66—PLANER TYPE MILLING MACHINE—GEO. WILKINSON & SON

requires little explanation. It will be noticed that the headstock pillar and base are all a single casting, and that the overhanging arm passes through a tube. The spindle, which is 2¾in. in diameter, is driven by a three-step cone and a 12 to 1 back gear. The bearings are conical, of hard gun-metal, and a tail pin is provided to take up end thrust. There are six positive speeds driven by a chain. The knee slides on faces with square edges, and the table is provided with the usual hand and automatic movements. It has tee slots, and a channel is fashioned round it to draw off the lubricant. The longitudinal feed is self-acting, and is fitted with an automatic knock-out motion which can be set for any part of the stroke; the transverse is effected by the handle in front of the knee bracket. The knee rises and falls on a square-edged slide. The longitudinal traverse is 2ft. 9in., the transverse

A machine of the planer type, by the same makers, is shown in Fig. 66. It has a bed of strong box section 1ft. 10in. deep, 1ft. 8in. wide, and 8ft. long, with square slides 2ft. across, accurately planed and scraped, on which is fitted a table 5ft. 9in. long by 3ft. wide, having a water trough all round, and provided with planed tee slots. The cut is effected by worm gear with mitre wheels for quick return motion. The feed of the table is 5ft. It is variable from $\frac{5}{16}$in. to 7in. per minute, and has a quick movement in either direction of thirty times the feed. The spindle is 4in. diameter, runs in a gun-metal conical bush, and is provided with friction washers for taking thrust in either direction. It has also an axial adjustment of 1½in. by means of screw and hand wheel, and is fitted with powerful locking motion; it is driven by spur and bevel gear, giving a wheel power of 23 to 1, and is carried on a strong saddle, fitted on a standard with planed and scraped vees, and is raised and lowered 3ft. by a screw. The standard carrying the saddle is of box section, and is bolted to the side of the bed, to which it is jointed by a strong lip and groove. At the opposite side of the bed is a standard, which will slide to and from the table, and is fitted with an outer bearing for the mandril; this bearing is raised and lowered on the standard at the same time, and by the same handle as the spindle saddle. The two standards are fixed together at the top by a stay, which can be firmly locked in any position. There is also an extra stay fitted to the saddle for carrying an outer support for short mandrils; this stay may be readily taken away, as desired, without disturbing any other portion of the machine.

In the milling machine by J. Parkinson and Son, of Shipley, which is illustrated by Figs. 71 and 72, the principle of preserving the complete box form of the pedestal is carried out. The cupboard which is, or was, usual in most designs, is now absent, and the column is, by the absence of the doorway, rendered stiffer and better able to meet modern strenuous conditions. The cabinet itself is, however, not sacrificed, being attached to the side of the column, and is actually larger than in older designs. The knee bracket is also as far as possible of complete box form, and the elevating screw is of the telescopic form. There are sixteen changes of feed, ranging from ½in. to 14¾in. per minute, obtained by the manipulation of a hand wheel and two levers, and a reverse to all motions controlled by a handle on the knee bracket. The feeds are driven from the countershaft, and provision is made for cutting them out should the spindle stop accidentally or intentionally. The arrangement is as follows:—A fast and loose pulley are mounted on a spindle on the change-feed box. The feed belt can be guided from one pulley to the other by a fork which is connected with a tension spring tending always to put the belt on the loose pulley. When the belt fork, which is shown at A, is moved in the other direction, the catch shown at B engages with it and holds it so that the feed belt runs on the tight pulley, and as long as the machine spindle rotates the belt remains there. If, however, the machine spindle ceases to rotate, the lever C, which is controlled by a centrifugal governor, moves in the direction shown by the arrow, and lifts up catch B, to which it is connected by a light chain. The belt fork A being thus liberated, the spring moves it so as to guide the belt on to the loose pulley. This takes place whenever the spindle is stopped, either by accident or intention, and when re-starting the machine it is necessary to move the belt fork A, either



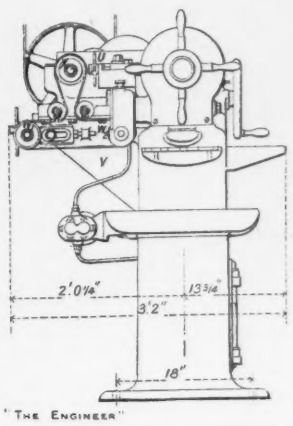


Fig. 67—CAM MILLING MACHINE

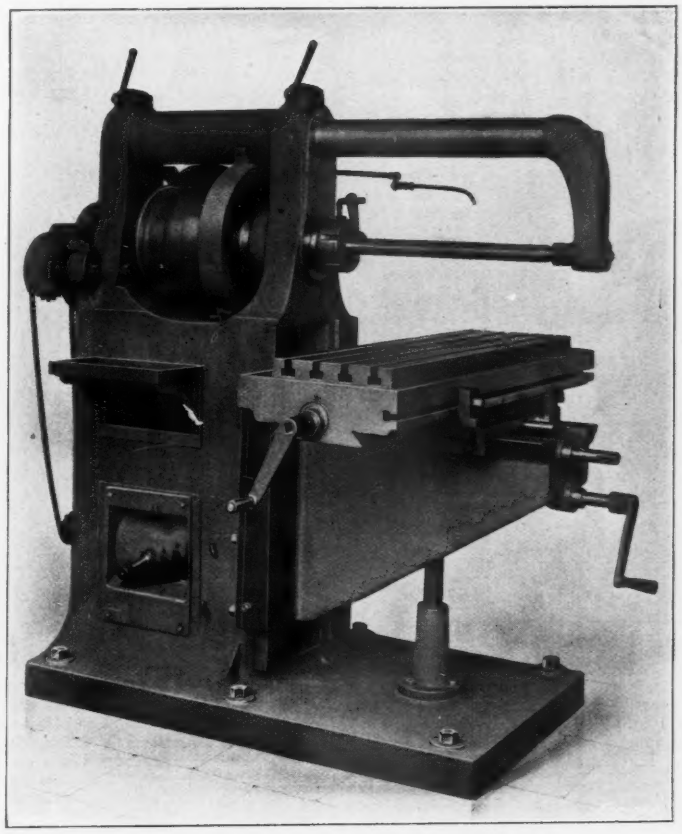


Fig. 68—MILLINC MACHINE—GEO. WILKINSON & SON

by hand or by means of the pedal shown at D. The table, which measures 53in. by 12in., is fitted with a screw of large diameter and ½in. pitch, and a quick return gear is fitted at one end. The traverses are 36in. by 10in. by 20in. With a two-speed countershaft, eighteen spindle speeds, ranging from 13 to 400 revolutions per minute are obtainable, there are two ratios of back gear—1 to 3·28 and 1 to 11·2. The front spindle bearing is 3½in. diameter and the rear bearing 2⅜in.; the overhanging arm is 4½in. diameter. The headstock is in one piece with the pedestal, and the two bearings are held together by the cylindrical brace at the top, through which the overhanging arm passes. The arm is clamped by split bearings in the usual way, and here, as in all the principal working parts of the machine, the nuts are provided with handles, so that no spanners are required. An intermediate support is put on the arm, and an outboard stay is also provided. The position of the gear box is well seen in Fig. 71, and it will be observed that the feed is transmitted through a substantial telescopic shaft with universal joints.

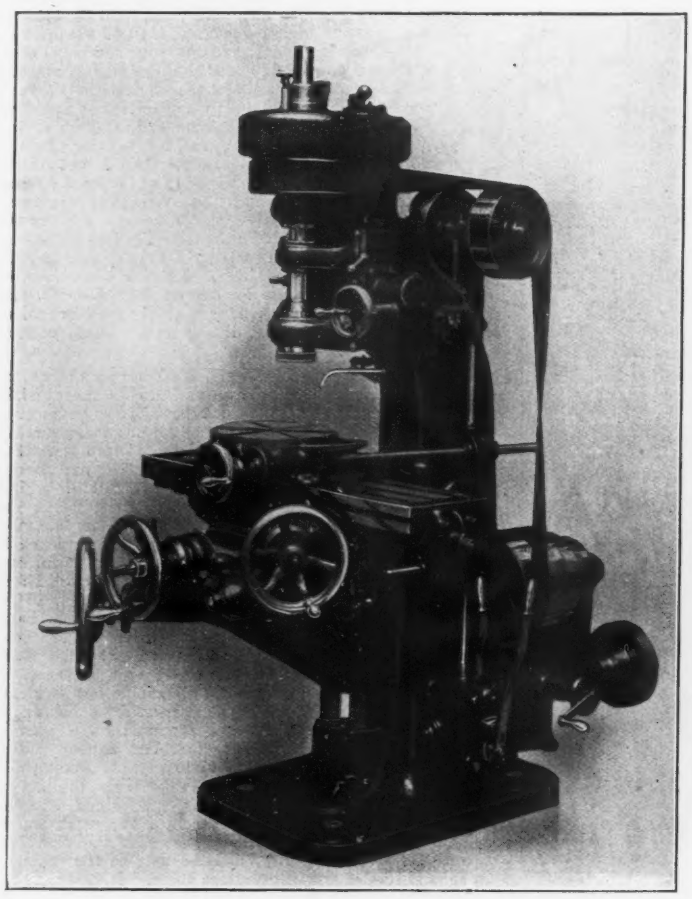


Fig. 69—VERTICAL MILLING MACHINE—H. W. WARD & CO.

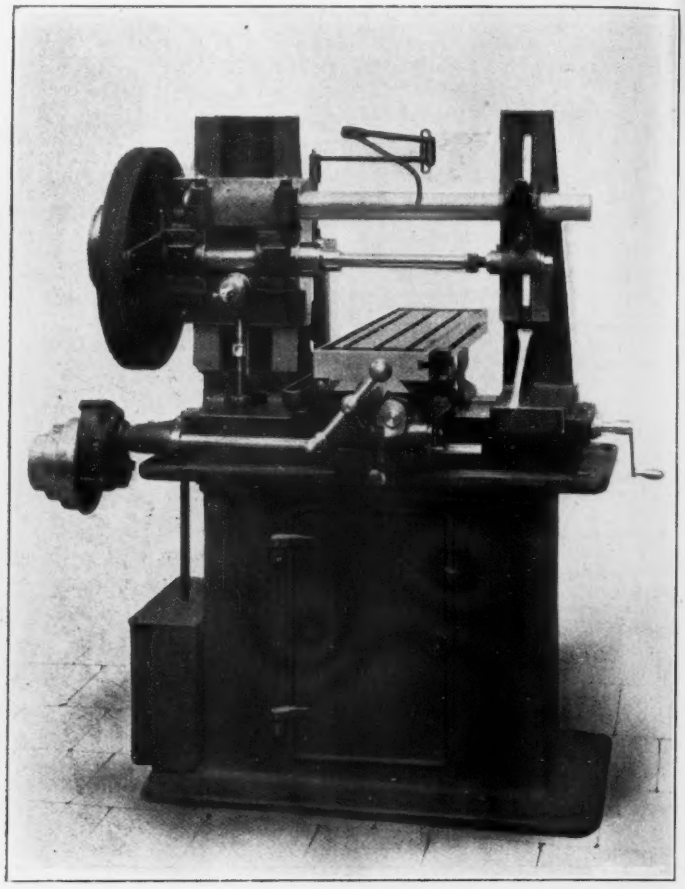
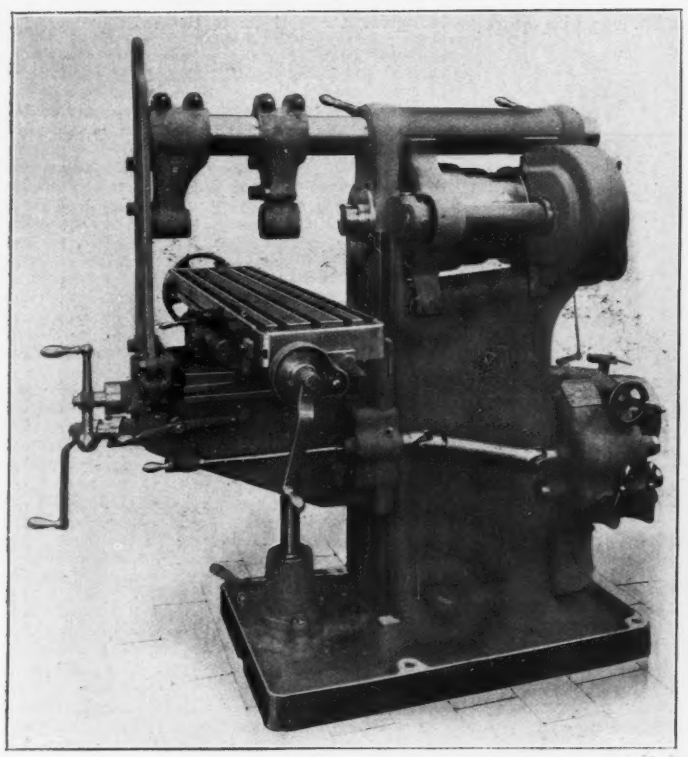
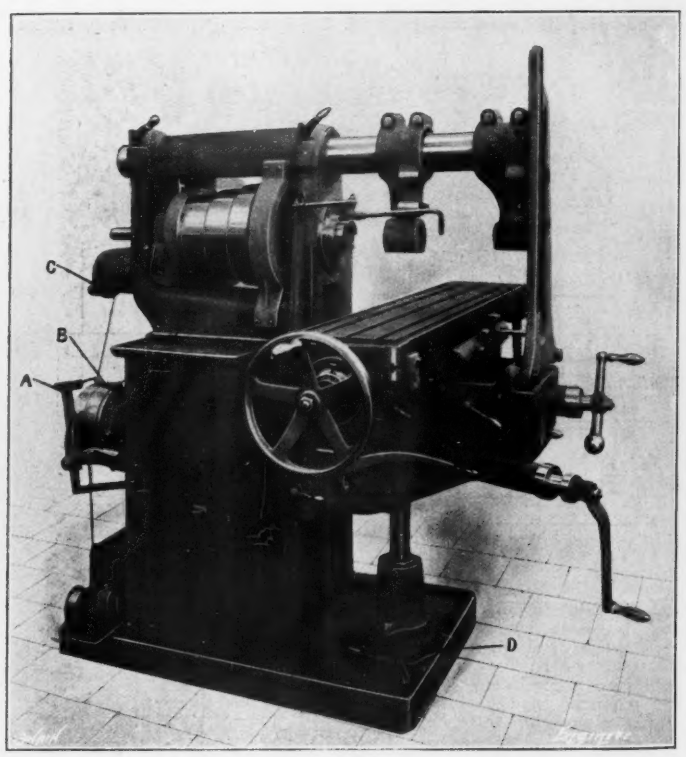


Fig. 70—HORIZONTAL MILLING MACHINE—H. W. WARD & CO.





Figs. 71 and 72—UNIVERSAL MILLING MACHINE—J. PARKINSON & SON

THE APPLICATION OF HIGHLY SUPERHEATED STEAM TO LOCOMOTIVES.

By Robert Garbe, Privy Councillor, Prussian State Railways.

No. VI.*

CONSTRUCTIVE DETAILS OF THE HOT STEAM LOCOMOTIVE.

For the use of highly superheated steam it is essential that all parts of the engine with which it is brought in contact, such as cylinders, pistons, stuffing-boxes, slide valves, &c., shall be constructed in such a manner as to meet the special properties of that medium. Although as in the case of other novelties, particularly in locomotive building, this was attended with considerable difficulty at first, such difficulty has now been overcome.

(*a*) Cylinders and Pistons.

In the design of the hot steam cylinder particular care must be taken to avoid all sudden alterations of section likely to cause irregular expansion of the structure by heat, and the body of the cylindrical slide valve chest must be kept entirely separate from the cylinder in order that the latter may not be more highly heated in the parts nearest to the admission ports than in those nearest the exhaust ports.

After a long and troublesome series of experiments with a view to obtaining a tight working piston as nearly frictionless as possible, a simple modification of the well-known Swedish piston has been obtained—shown in Fig. 11—and has given extremely satisfactory results.

This success is due to the fact that the three light packing rings bear none of the weight of the body of the piston, their function being merely to form a steam-tight joint by their slight elasticity and the small pressure acting behind them jointly. Three rings are used in order that the middle one may never be subjected to back pressure. Each of the rings is perforated radially by six holes 3 mm. in diameter, spaced at equal distances apart, and opening into a shallow groove turned into the outer surface, giving a series of passages from the front to the back of the ring. When, therefore, at the change of stroke the first or third ring is driven by compression out of contact with the cylinder, steam makes its way behind it through the small exposed passage and presses it back, a too sudden restoration of the contact being prevented by the reflex action of part of the steam flowing back into the groove and cushioning the blow. Furthermore, a small amount of steam finds its way between the ends of the second and third rings and their seats on the piston, relieving the pressure sufficiently to ensure merely a light contact with the side of the cylinder.

The piston body, cast of the highest quality of steel, is made as light as possible. Both the outer and inner edges of the ring seats are rounded, the former somewhat more than the latter, to facilitate distribution of the lubricating oil. The diameter is made about 3 mm. less than that of the cylinder to prevent cutting during withdrawal, and also when from wear in the stuffing-boxes the piston is no longer perfectly central. Neither the body of the piston, the packing rings, nor the stuffing-boxes must at any time carry any part of the weight of the piston. The piston-rod has a special guide in front, and is carried behind by the crosshead so that the piston is kept nearly floating in the cylinder.

(*b*) Piston-rod Stuffing-boxes.

With hot steam the use of metallic packing with free lateral motion for the piston-rod is essential. A packing, which has been quite successful, is shown in detail in Figs. 12 and 13.

If the piston is kept centred as closely as possible by proper packing of the crosshead slipper and timely renewal of the forward guide-bars, which measures are absolutely necessary for proper and regular working, the stuffing-box packings will run for years with extremely small wear in any of their parts.

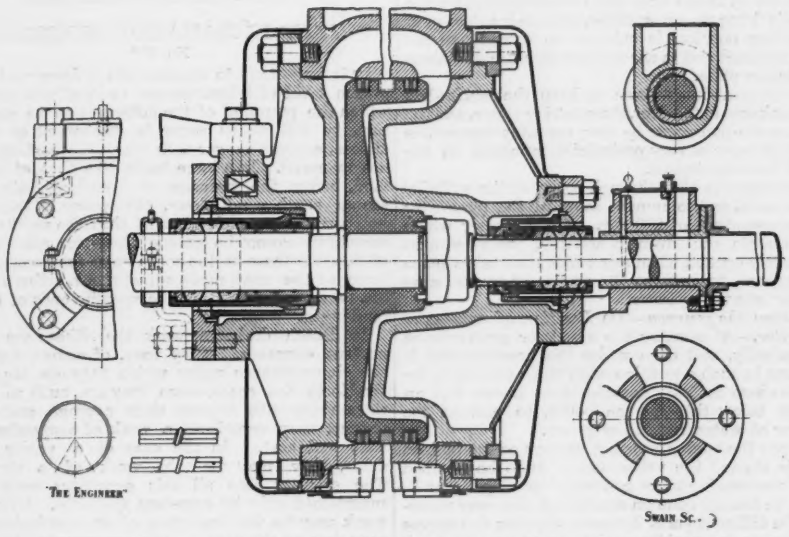


Fig 11—PISTON AND STUFFING BOXES FOR SUPERHEATED STEAM

(*c*) Piston Slide Valves.

In all hot steam engines piston valves should be used, the steam being admitted from the inside, giving a naturally balanced construction. This does away with the necessity of stuffing-boxes in the slide valve box, as the outer surfaces of the slide are only under the low pressure of the exhaust steam, which is absorbed when a sufficiently long channel or labyrinth packing is used. These valves are constructed in two principal forms.

1. Piston valves with solid rings, double admission and steam jacketed valve chest.

2. Piston valves with partly counterbalanced spring rings and slide cover under steam pressure.

The first of these forms is that principally used by the Prussian State lines, while the second is favoured by most of the other railways using superheated steam.

Internal admission which does away with the necessity of stuffing-box guides and partially balanced spring packing rings or solid rings are recommended, it being especially important to avoid the generation of heat by friction in the running parts as completely as possible when highly superheated steam is used.

(1) Piston Valve with Solid Rings, Double Admission, and Steam-jacketed Valve Chest. (Schmidt's Design. Fig. 14.)

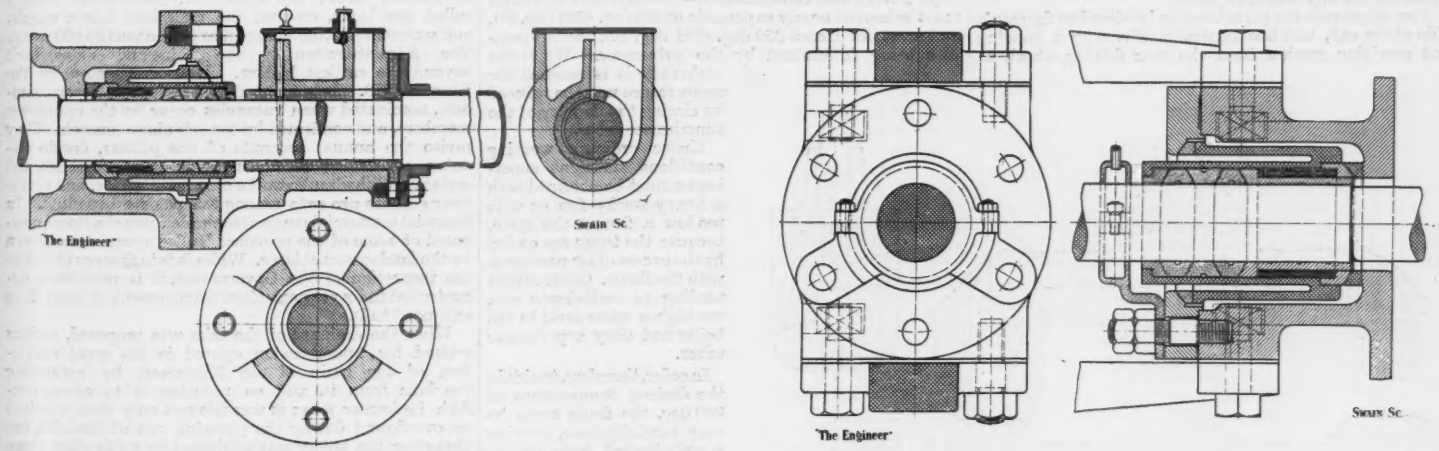
In this valve the rings are undivided, and are closely fitted by grinding to gauge, being, as is the slide rod, kept tight by labyrinth packing—grooves—alone. With this arrangement the slide valve can be readily moved by hand, whatever may be the steam pressure in the valve-box, the resistance being so small that all the motion parts may be made considerably lighter than formerly, while their durability has been notably increased.

As at first constructed, however, difficulties were experienced from irregular expansion between seat and valve, and it became necessary to keep the diameter of the slide as small as possible. This has been done by using double admission ports, and the valve chest has been jacketted and heated with the highest temperature steam. These modifications have made it possible to adopt a single size, 150 mm. in diameter, of valve for the whole of the hot-steam locomotives of the Prussian State lines, even in the 3/5 coupled express engines with 590 mm. cylinders. That these small valves run at the highest speeds without excessive throttling is to be attributed to the extreme mobility of the steam when highly superheated, and the advantage arising from the adoption of a single standard size of valve for all classes of engines will be apparent without further comment.

With regard to the objection raised by many authorities to valves of the construction described above, on the ground of leakage, it must be remarked that the loss of steam measured when at rest is no measure of that taking place when running. These long close rings necessarily allow a considerable amount of steam to pass as a condition of maintaining their frictionless floating character when at rest, but such leakage decreases rapidly with increase of speed when in motion. A thin film of oil works into the clearance space between the valve and casing, forming a perfectly satisfactory packing. Rings that have been long in use show no perceptible wear, but, on the contrary, their diameter may be slightly increased by a thin, compact deposit from the carbonising of the lubricating oil on such parts as allow of its formation. This fact has been frequently observed. Finally, it may be remarked that small leakages into the cylinder during the admission and expansion periods are not prejudicial, and the loss during compression can only be insignificant. At any rate, the small power sacrificed from this cause bears no relation to the much greater amount required to work large flat valves or heavy unbalanced piston valves, to say nothing of the much greater wear and tear of the latter.

(*d*) Pressure Equalising Arrangement (Fig. 15).

Piston slide valves have the defect that, unlike flat slides, the pressure on the seat is not diminished during running when the steam compression becomes too high. To avoid the injurious shocks in the rods and motion due to this cause, hot steam locomotives are provided with the contrivance shown in Fig. 15. This is a by-pass tube 60 mm. bore, connecting the two ends of the cylinder with a cock in the centre. When the steam regulator is closed this is opened, and the pressure on both sides is equalised. This cock is steam-heated, and to prevent it becoming fixed on its seat it is only loosely fitted, the steam pressure from either side keeping it tight in its place during running. The valve stem is connected by a grooved and dovetailed slide, and the grooves turned in the outer guide form a labyrinth packing, and so dispense with a stuffing-box. This is worked by hand with a key on the square end of the stem, and has taken the place of a former self-acting arrangement, which was not found to work satisfactorily. The driver has to open the passage immediately on closing the regulator and must close it again before re-admitting steam to the engine.



Figs. 12 and 13—STUFFING BOXES FOR SUPERHEATED STEAM

(*e*) Lubrication.

A matter of primary importance in the use of hot steam in locomotives is the provision of appropriate lubrication for the parts working under steam—the piston and slide valves—which, both in regard to material and arrangement, call for special modification in details.

The high temperature makes it necessary to use only pure mineral oils of particularly high flash points, which must be supplied in determinate quantity according to the speed, *i.e.*, the revolutions of the driving wheels, to the rubbing surfaces. It must be prevented from becoming mixed with water, or heated and decomposed by steam, both of which effects are more or less likely to occur with drop or sight feed lubricators. The access of condensed water to the surfaces to be lubricated is injurious to working parts, and is a cause of waste by the steam carrying finely divided oil to parts not requiring to be greased.

A further objection to drop lubricators in hot steam work

* No. V. appeared November 22nd.

is to be found in their inflexibility, the oil being distributed by a continuous flow from one or other end of the supply pipe in the direction of lower pressures, irrespective of the requirements of the surfaces. Now for successful lubrication, it is essential that it shall be possible to meet all variations of pressures on the rubbing surfaces by varying the supply of oil as necessities may arise. These considerations have led to the exclusive adoption of pressure lubricators. As the oil has to be supplied to three places on either side of the engine, two slide and one engine piston, the oil presses must be fitted with six cylinders, and the

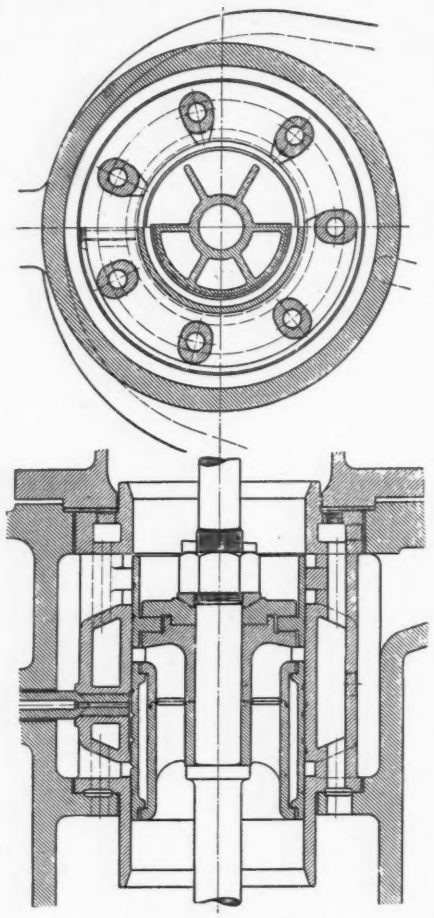


Fig. 14—PISTON VALVE

communication pipes must be kept constantly filled and kept under pressure, with appropriate return valves at the distributing points. The return valves or oil savers are important features in the arrangement, preventing irregularity of flow from changes of pressure in the places to be lubricated, and the waste of the oil from the supply pipes when the engine is standing or running without steaming for any length of time.

The oil presses are placed on the left-hand or fireman's side of the cab, and are generally driven by a hanging rod receiving motion from the rear driving wheel, so

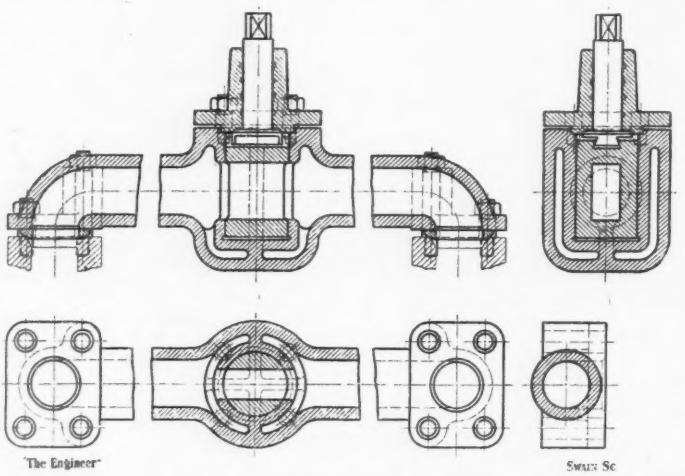


Fig. 15—PRESSURE EQUALISING PIPE

that they are only at work while the engine is running. The regulation of the oil supply is effected by varying the effective length of the rod.

Oil presses by the following makers are adopted on the Prussian railways:—Ritter, in Altona; Michalk, of Deuben, near Dresden; and Dicke and Warneburg, of Halle; while in Austria the Friedmann oil pump is generally used. These have proved to be perfectly efficacious in use, and allow any desired rate of consumption to be easily and certainly attained. It is, however, essential that their action shall always be tested before starting by means of the small test cocks placed below the return valves.

(*f*) Special Equipment Details for Hot Steam Locomotives.

In addition to the items described above, certain special fittings are required for the hot steam locomotive. These include a pyrometer and a pressure gauge for determining the superheat and pressure at the valve chest, a smoke-box vacuum gauge, and a hand rod for the pressure equaliser, placed near the hand wheel of the valve gear. The handle for regulating the superheater flap valve is placed on the left-hand side of the fire-box.

(*g*) Special Working Regulations for Hot Steam Locomotives on the Prussian State Lines.

I.—*Before starting.*—(1) The oil presses, which, in accordance with the instructions supplied to each engine, are to be filled with oil at the end of the journey, are invariably to be tested as to their working condition before starting on a new journey. The strainer in the feed vessel is to be cleaned out at short intervals, and the presses are to be kept scrupulously clean.

(2) The self-acting valves of the smoke tube superheaters are to be kept clean and completely shut while the engine is firing up or standing, and their adjustment to the working position is only to be done when the regulator is opened and in accordance with the directions of the indicator plate.

(3) It is of great importance to keep the smoke-box tight. All leakages in the door, the covering plates, and the flange of the ash-pan must be very carefully stopped, as such leakages have a very prejudicial influence on the working of the superheater.

(4) At starting the blow-through cocks of the cylinder are to be opened, and to remain so until the pyrometer shows a temperature of 200 deg. or more, after which they may remain shut even at starting, but they must be immediately opened when any sudden fall takes place in the superheat, to prevent the chance of water being carried over into the cylinder.

II.—*During the journey.*—(1) *Position of valve gear and regulator.*—At starting the regulator must only be opened gradually, and even under the heaviest load it must be kept in such a position that the pressure in the slide valve chest is kept constantly at about half an atmosphere below that in the boiler, to prevent the passing over of water into the cylinders.

To prevent the engine slipping as soon as the pull on the train is started the valve motion is to be notched back, and the starting to be controlled principally by it, which can be readily done on account of the easy movement of the different parts by hand allowing the degree of admission to be rapidly varied, so as to prevent all slipping while maintaining a powerful starting pull.

The admission in the cylinder is never to be reduced below two-tenths of the stroke. When smaller power is required the steam pressure must be throttled down from 1½ to 2 atmospheres, keeping the valve gear sufficiently forward to ensure easy running.

On shutting the regulator the valve gear must not be immediately laid off, and to prevent jamming and cutting, it must only be put in forward gear after completely stopping. In all cases, however, when coming out of the shed the gear must be put full forward to ensure the proper distribution of the lubricating oil over the surface of the slide, as well as blowing out dirt and coagulated oil.

The pressure equaliser on the driver's side must always be opened immediately after closing the regulator, and when the engine is standing immediately shut again, without altering the position of the valve gear.

(2) *Firing and superheating.*—The average superheats must be kept as nearly as possible at 320 deg. (608 deg. F.), and must not exceed 350 deg. (698 deg. F.), the temperature being determined by the pyrometer. When the highest limit is reached the temperature must be reduced by closing the damper of the superheater tubes.

Under ordinary working conditions sufficient superheat cannot be obtained with a heavy smoky fire or with too low a fire on the grate, because the tubes are cooled by the excess of air passing in with the flame. Other causes tending to inefficiency are, too high a water level in the boiler and dirty superheater tubes.

In order, therefore, to obtain the desired temperature of 320 deg. the firing must be very carefully done, keeping a well ignited body of fuel on the grate and adding fresh coal by a few shovelsful at a time, making the largest additions at the back and to the under corners of the fire-box and below the fire-door. It is absolutely necessary that the firing shall be done more frequently than with compound engines, and as a rule the water should be pumped up after each firing, care being taken that the fire never becomes low enough to allow air to penetrate through bare spaces on the grate.

A sudden drop in temperature is always experienced when the steam carries water over into the superheater, which often happens with turbid and dirty feed-water. This can only be remedied by thoroughly washing out the boiler. With a proper use of the regulator the flow of steam may be so arranged as to deliver it as dry as possible to the superheater. The proper degree of throttling for this purpose is ascertained from the indications of the pressure gauge on the slide-valve box.

III. *After the journey.*—The superheater tubes are to be cleaned from soot and ashes by introducing the nozzle of a hose connected with a steam or air pipe into the superheater tubes from the back. This may be done either with steam from the boiler or compressed air from a special supply at 150 lb. pressure, that from the reservoirs of the Westinghouse brakes not being sufficiently high. When the boiler is cold compressed air only must be used, as the condensation from steam on the cold tubes is likely to rust them. The length of the interval between cleaning periods depends entirely on the quality of the coal. Whenever the boiler is washed out any accumulations of slag that may have formed on the back ends of the superheater tubes are to be cleared out from the fire-box side, and the spark catcher is to be taken out in order to see if any incrustation of soot has formed on the rim of the blast pipe. If this is the case the lubrication is too heavy, and the discharge of the oil pumps must be proportionately reduced. Washing out or sprinkling the superheater, since it leads to rusting, is absolutely forbidden.

LAND RECLAMATION IN HOLLAND.

No. II *

It is important to consider the influence of the wind on the level of inland waters as it affects the level at which the pumping of the polders is to be stopped, the rapidity with which water is discharged at the outlet sluices, and the danger with which the containing banks are menaced. In a large basin like that of the Rhineland, before the drainage of Haarlem Lake, when a strong south wind blows, the water is raised in the northern part to such a height that the northern polders sometimes cannot be pumped, however great their need of it, while those at the south have ample margin. The force of the wind made sometimes a difference of over 3ft. between the levels at the opposite ends of the Rhineland basin.

In Dutch drainage work the dikes are very important elements. They vary, of course, according to the circumstances under which they are required. On the North Sea coast, when they are built to withstand tides rising 10ft. beyond their average, and lashed by storms, they constitute a work of stupendous magnitude and cost. In the case of a polder of a few acres, they may be the work of a single man. The security that all this enormous work affords is maintained only by ceaseless vigilance. Even a mole-track may be the beginning of an inundation that will soon destroy the whole. As a consequence, the engineering supervision and control of all public hydraulic works assumes an importance in the Netherlands nowhere else known.

The standard of all water measurement in Holland is a bench mark at Amsterdam, showing the ordinary level of water at that point. It is indicated by the letters A P. (Amsterdamsche Peil), and is the zero point to which all hydraulic descriptions of Holland refer. It is 2ft. 4in. above ordinary low water, and about 2ft. 7in. below ordinary high water. Levels above this bench mark are indicated by + A.P., those below by – A.P. The Rhineland is protected against the North Sea by high sand dunes along the coast, and against the Ij by a vast dike stretching along its southern shore from the dunes to Amsterdam, its crest being nearly 10ft. + A.P. Before the drainage of Haarlem Lake this administration covered over 300,000 acres, 75,000—including the dunes—being naturally above the water level, and 175,000 polders or drained lakes; the remainder, constituting what is called the basin, covered the undrained lakes, canals, and watercourses, including an area of about 55,000 acres. The Administration of the Rhineland dates back beyond the earliest history. It was recognised by the King in 1253. It is directed by a college of seven members, nominated when vacancies occur by the remaining members, and confirmed by the reigning monarch. They revise the annual accounts of the polders, decide disputes concerning questions of drainage, establish and maintain all hydraulic works of general utility, and divide their charges *pro rata* among the polders benefited. In financial matters it is subject to the decision of a Board composed of some of the principal landed proprietors chosen by the landowners at large. While it is in theory subject to the inspection of the Government, it is practically uncontrolled in its very excellent management of the affairs entrusted to it.

When the drainage of the lake was proposed, serious ground for apprehension existed in the great restriction of the basin of the Rhineland by separating the lake from it, and so reducing it to about one-fifth its former size; it was felt not only that it might be overflowed during the pumping out of the lake, but that after the polder was subjected to cultivation there would be, during summer droughts, too little water available for the necessary supply of its canals and ditches. This apprehension could be met only by theory, and the administration of the Rhineland, naturally jealous of its rights and impressed with its duties to its constituents, was slow to concede its permission for the execution of the plan.

A long discussion resulted in a contract between them and the Commission, acting on behalf of the Government, which was exceedingly strenuous in its restrictions, and illustrates the degree to which the Government defers to the Hydraulic Administrations, on which so much of the safety of the country depends. It is difficult for those not familiar with the drainage of Holland to understand how the question of a half inch more or less in the elevation of the water should become a question of State. This contract held the Commission to the strictest responsibility, and required them to stop the action of their pumps whenever the basin should rise higher than 8·4in. in winter or 11·2 in summer — A.P. They were required to establish such works as might be necessary

* No. I. appeared November 15th.

to supply fresh water from without whenever in dry weather the basin should descend lower than 17in. — A.P.

As fast as the drained lands were put in cultivation they were to pay to the Administration their proportional taxes. The drainage being completed, the polder was to form a part of the territory of the Administration, this body having also the same control of the navigation of the encircling canal that it had of other waters within its districts.

The drainage of all the large polders of Holland is an interesting subject of study, but all the others sink into relative insignificance when compared with Haarlem Lake, which, being the largest work of its kind in the world, is selected for the illustration of the system followed. This lake has always been a source of great danger to the cities of Amsterdam, Haarlem, and Leyden, and the known fertility of the soil at its bottom was always a strong temptation to enterprising improvers. Schemes for its drainage date back for more than two and a-half centuries.

As long ago as 1643 a mill builder named Jan Adriantz—surnamed Leeghwater—published a detailed plan for its drainage, which passed through thirteen editions—the latest in 1838. Leeghwater proposed an enclosing dike with a canal outside of it, but he omitted a portion of the southern end—the Kager Meer. He proposed to use 160 windmills, 40 upon each of four different elevators raising the water from one to the other. The outlet of the basin of the Rhineland at Katwijk did not then exist, the Rhine having been closed with silt and drift. Another similar plan appeared about the same time, and then the question rested for a century. In 1742 the engineers of the Rhineland prepared a new plan, leaving out not only the Kager Meer, but also the Spiering Meer at the north. They proposed the use of 112 windmills. After that time the subject was frequently discussed. It had much attention from the Government, and many modifications of the plan were proposed, some greatly extending the boundaries of the land to be drained. The first proposal to make use of steam as a motive power was made by Baron Lijuden, who recommended eighteen steam engines to drive rotating paddle-wheels, similar to those used with windmills. As time passed on, plans and descriptions multiplied, and the use of steam alone, or as an accessory to wind power, was more and more considered.

During the whole two centuries there were fifteen well studied plans submitted to the public or to the Government. Final action was stimulated by the repeated hurricanes of the autumn of 1836. On November 9th a fierce westerly gale drove the waters of the lake violently upon Amsterdam. They swept across the polders, and above the roads and dikes, to the very walls of the capital. On Christmas Day another storm blowing from the east carried the waters of the lake toward Leyden, submerging a part of the city. The waves broke the dikes, or poured in cascades into the deep polders. In November, near Amsterdam, the water rose nearly 3ft. + A.P., and flooded nearly 100,000 acres of polders. In December an equal height was attained, over 18,000 acres of polders being inundated. Even with extraordinary cost and energy, it was more than a year before the submerged lands were made dry again. This was the deciding circumstance which resulted in the formation of the commission for the drainage of Haarlem Lake.

The chief area of the modern Haarlem Lake was formerly an inhabited country. According to an old map of 1531 there were at the time only four small lakes. Two roads crossed the whole extent, and there were three flourishing villages. These lakes occupied altogether less than one-third of the modern area. In 1591 one of these villages had already disappeared, and in 1647 the others had gone, and the four lakes had run into one. The cause of this continual loss of land is to be sought in the exceedingly fine and siltable condition of the soil, which is readily moved by moving water, and yields rapidly to the force of strong waves. The soft bed of the lake is tolerably uniform, and was covered with rather more than 13ft. of water. The firm soil lay more than 16ft. — A.P. The plans which were finally adopted for the drainage of the lake involved :—

(1) The building of a huge dike entirely around the lake for a distance of about 37 miles, and outside of this a canal, 131ft. wide, serving the double purpose of affording a channel for the active navigation, now to be excluded from the lake, and for the escape of the water of drainage during and after the formation of the polder.

(2) The enlargement of the canal and lock at Katwyk to secure the more rapid escape of the waters delivered at that point.

(3) The erection of a steam pumping station at Spaarndam and Halfway, to secure the more rapid discharge of these outlets into the Ij, and to prevent the interruption of the flow on the occasion of unusual rises of the water in that arm of the sea.

(4) The erection of another pumping station of like character at the southern border of the territory of the Rhineland, at Gouda, to improve the drainage of the polders of this region—this not necessarily as an aid to the drainage of the lake itself, but as an inducement for concessions on the part of the administration of the Rhineland.

(5) The establishment of three pumping stations at the borders of the lake, each supplied with lifting pumps worked by large steam engines specially designed and constructed for the work. One of these pumping stations, "The Cruquius," was fixed at the junction of the Spaarne with the encircling canal and the other two at the ends of the longitudinal axis of the lake—"The Lijnden," opposite the Lutkee Meer, and "The Leeghwater," at Kaag. The estimated cost of the enterprise was 8,355,000 gulden (£668,000, or about £15 per acre for the land to be reclaimed). The scheme was finally adopted by the States-General by an immense majority in 1839. The commission charged with the work comprised thirteen distinguished engineers, landed proprietors, and State councillors, under the presidency of Gevers d'Endegeest.

The dike was entirely to isolate the lake, without locks for the admission of boats to the canals of the future polder. It was to be a simple embankment on the firmer ground bordering the lake, but protected by loaded caissons sunk in the creeks and canals which it crossed. These works under water covered a length of nearly two miles, and presented in many cases serious engineering difficulties. For a width of 95ft. the canal has a depth of over 10ft. The dike rises to a height of 7½ft. + A.P. The banks of the canal have a slope of 2 to 1, and are bordered by a level strip about 6ft. wide, which is slightly covered by water. Between the canal and the dike of the lake on one side, and the dikes of the adjoining polder on the other, there is a level roadway. The body of the dike is generally composed of the peaty earth thrown up in the excavation of the canal. It is covered with turf, and has generally sunk but little, the heavy weight of the mass in construction having at once compacted it firmly. In exceptional cases it has been necessary to restore its height from time to time—generally with the silt taken out in cleaning the canal. The narrow tongue of land separating the lake from the peat lakes lying to the south-east of it was not land in the true sense of the word, only a narrow floating bed composed of a variety of aquatic plants whose roots were closely interlaced, and which rose and fell with the level of the basin. This was gradually loaded with the earth taken from the canal and sunk little by little to the hard bottom 12ft. or 15ft. below. Upon this, as it solidified, the body of the dike was finally built. The result was entirely satisfactory, and the cost was not excessive. Occasionally it was necessary to build walls of fascines—sunken caissons—and occasionally heavy deposits of sand were brought at great cost from the dunes on the opposite side of the lake.

In October, 1843, the lake was entirely closed, with the exception of certain openings left for navigation, the final closing of which awaited the completion of the machinery and the consent of the Administration of the Rhineland. It actually took place in May, 1848. The dike and canal cost £161,527. Their length is 37·02 miles. The average cost for canal and dike together was 16s. per running foot. The superficial area of the canal is 654·36 acres, and the area of the dike and its slopes is 1013·52 acres. During the early stages of the work, before the dike had settled and become covered with vegetation, it was subject to considerable washing by the water of the canal, and had frequently to be protected by basket work of straw and rushes.

After its completion, in 1848, it needed no repair save occasionally slight additions to its height at certain points where it had settled or had lost material by accidental fires. A curious phenomenon, however, occurred in connection with the outer dike of the canal on the east side of the lake, where it crossed an area of floating soil which bordered wide ponds near the village of Aalsmeer. An area of many acres, detached by the canal from the old works of defence against the lake, found itself one fine day driven by the tempest from the bank of the canal to the other side of the pond. The proprietor implored the aid of the Commission. His land had floated to the opposite shore, widely separated from his other fields, and resting on water that was not his own. By the combined effort of the proprietor and of the Commission these fugitive fields were towed back to the borders of the canal, and pinned in place by piles and poles, which prevented them from undertaking another voyage.

The question which required the most careful consideration, and the decision of which involved the greatest responsibility, was that of the exclusive use of steam power for pumping. The amount of water to be lifted was over 780,000,000 tons. To this must be added the rainfall and the water of infiltration, which was estimated to amount to 48,000,000 tons per annum during the drainage of the lake, and 60,000,000 tons after the drainage. There had, however, to be taken into account the necessity for the rapid removal of the greatest additions the waters of the polder might receive under the most unfavourable circumstances. Provision was consequently to be made for the removal of 40,000,000 tons per month. The lowest water level of the canals and ditches after the draining would be 16ft. — A.P. This would constitute a task for the full capacity of 100 windmills of the largest size. A serious objection to the use of these was found in the fact that a pumping windmill works effectively only 1500 hours in the year ; the rest of the time—during the wet season—the wind is too strong or too light. In using windmills with the Archimedean screw, with which the lake could be emptied in two lifts of about 7ft. each, it would have been necessary to have fifty-seven mills on each lift. The upper lift would have required fifteen months for its removal. The second lift could be moved only so fast as the mills of the upper could lift the water for the whole height of 7ft.

This would have required thirty-three months for the removal of all the water of the lower lift. Draining by wind would therefore have required four years' time. Steam would be able to remove the whole in fourteen months, allowing 250 actual working days per annum. Each windmill would cost £2175, and would each cost £62 per annum for maintenance; making a total, including interest, of £308,333. It was calculated that the removal of 40,000,000 tons per month would be accomplished, with the use of pumps, by steam engines having a combined force of 1084 horse-power. In adopting steam as the motive power, the Commission undertook a work on a scale larger than had ever before been attempted. There was no model to follow at home or abroad. The experience of the mines of Cornwall had demonstrated that the larger the steam cylinder—at least up to a diameter of 80in.—the less was the fuel required for the production of a certain force ; that direct-acting engines with pumps gave the most advantageous results; that such engines of 80in. cylinders could raise 650 tons of water 3ft. high, with the consumption of 221 lb. of coal, being less than 2¼ lb. of coal per horse-power per hour. Making allowance for friction and all drawbacks, there was allowed less than 3 lb. of coal per horse-power per hour. The cost of draining by steam would be only £100,000. After the removal of the water the maintenance of the 114 windmills would cost £6200 per annum. The steam pumps—allowing fifty-three days' work per annum—would cost £4500. These calculations induced the Commission definitely to employ steam as their motive power, and, in default of all example, they decided to create an apparatus which nowhere else existed.

As Hollanders had been called to England, to France, and to Germany, for the construction of hydraulic works, they had no hesitation in employing English engineers to prepare plans of their pumping engines. The duty was entrusted to Messrs. Arthur Dean and Joseph Gibbs, who contracted to furnish complete plans for a steam engine with a double cylinder, the diameter of the inner one being 84in. Each engine should have a force of 350 horse-power, with ten strokes per minute, the length of stroke being 10ft., and capable of raising from 70,000,000 to 75,000,000 lb. 1ft. with the consumption of 94 lb. of coal of the best quality. They engaged further to superintend the construction and erection of the enine. Their compensation was to depend mainly on the success of their plans. They were to receive £250, whether the Leeghwater succeeded or not. To suceeed, the engine should be of at least 350 horse-power, should lift from 70,000,000 to 75,000,000 lb. to the height of 1ft., with the consumption of 94 lb. of the first quality of Welsh coal, the circumstances being the same as would obtain when the water had to be lifted from the whole depth of the drained polder. This result being obtained, they were to receive in addition £7585. For all greater result they were to receive £18 for each million in excess. The same plans being adopted for the Zijuden and Cruquins, they were to receive £750 for each of these engines.

The construction of the building to receive this machinery required the isolation by a circular dike of the spot intended for its foundation. This was drained and dug out to a depth of 23ft. — A.P. At the bottom of this deep pit there were sunk 1400 piles, 490 of them of oak being under the central tower, and soil was found so solid that it was impossible to sink them to the desired depth of 40ft. Sometimes twenty-five blows of a monkey weighing 1100 lb. moved them but the fraction of an inch. The floor, composed of timbers rather than of planks, was secured to the tops of the piles, and on this were begun the enormous walls of the edifice.

In three months 2½ million bricks were laid. The walls were not less massive than the foundation. They were to sustain at their upper part not only the eleven working beams in constant motion, each weighing 22,000 lb., but also the rods and plungers of the pumps, and the torrents of water that these were to lift—48,400 ib. when at the depth of 3ft., and more than 220,000 lb. at the lower limit of the drainage. The first trial of the Leeghwater engine was made in September, 1845. Those parts of the machine which came from England were perfect in every respect, although several of them were of a size until then unknown. The steam cylinder was the largest in the world. This cylinder, with an interior diameter of nearly 12ft., and a length of nearly 13ft., weighed 24·2 tons, the crosshead 18·8 tons. The eleven pump cylinders, 19ft. long and 63in. in diameter, weighed 6·82 tons each.

OUR MINERAL STATISTICS.

In accordance with established procedure, we make some comments herewith on Part III., "Output," of the Mines and Quarries General Report and Statistics for 1906.

With the exception of Cornwall, where, as is well known, a considerable amount of capital has recently been put into tin-mining, none of the mining districts, as far as the period under review is concerned, show any important expansion either in their output of ore or in the expenditure of capital on mines abandoned when less remunerative prices prevailed. Our prognostications in this direction in last year's review have been shown to be somewhat faulty, but then the financing of mining properties is not usually conducted at a breakneck pace, and with regard to lead, at any rate, the increased output which was adumbrated will assuredly be seen when the returns for 1907 see the light—this more particularly with regard to Teesdale and Flintshire, the operations in the Ystwyth Valley in Cardiganshire having hardly got beyond the initial stage. Except in the way of affording somewhat sensational copy for the daily Press, the predicted revival of lead mining in Derbyshire has come to very little, though it is interesting to note that the Magpie and Golconda mines are again producing ore. Of course, there are no returns yet from the goldfield in the Forest of Dean, now being exploited by the Chastan Syndicate, but the wary investor, when approached on the subject of British gold mining, can point to the recent returns from Merionethshire in support of his hesitancy. Since 1904, when the value of the gold obtained at the Merionethshire mines—mostly from the St. David's mine—amounted to £73,925, poor ground has been continuously met with, and it must be extremely disappointing to those chiefly concerned to have it announced to the world in these statistics that 17,384 tons of ore yielded only £6569 value of gold in 1906. In connection with gold production we note, by the way, that in a footnote relative to the Glentogher lead mine, in Donegal, it is stated that the ore contains gold and silver values. Last year we expressed our surprise at the value given in the returns to the very low-grade lead ore from this mine, after making due allowance for its silver contents. The reference made in the present volume to its gold values goes a long way, of course, to explain our mystification of last year. Without wishing to lay too much stress on worn topics, we still think that a less deprecatory tone might be adopted in the remarks on manganese production in Wales, the Carnarvonshire output showing such a great

and consistent increase. Chert, again, as supplied for grindstones in the Potteries, is still referred to as coming principally from Derbyshire and Flintshire, a statement which might lead the uninitiated to suppose that the stone from Swaledale, in the North Riding, was of little importance, either in quantity or value, compared with that from Flintshire — a most erroneous conclusion to arrive at. Of course, as the figures for chert and flint are all lumped under one heading, and as some of the chert is mined and some quarried, the returns are intelligible only to those directly concerned in the production. In our opinion, a separation, which would be a matter of no difficulty whatever, might be made in the interests of general utility.

But, to pass from the general to the particular, we propose to refer in alphabetical order to the more important metals and minerals which seem to invite comment. Commencing with arsenic, it is interesting to note that the Devon Great Consols—once such a noted copper mine—has again come into the lists as a producer of arsenical pyrites, which it yielded in such large quantities for many years after the copper ore gave out. Owing to the arsenical pyrites produced in Devon and Cornwall being in some cases roasted for oxide at the mine and in other cases sold, it is difficult for the compilers of the statistics to get accurate values. Moreover, there is the arsenic derived from the metallurgical treatment of complex tin and wolfram ores to be taken into consideration. Avoiding, however, any attempt at a close analysis of the figures, it is sufficient to note that the output of crude and refined arsenic was 1599 tons, which is only a trifle more than in the preceding year. The value, however, was considerably more, being £22,313 in 1906, against £7493 in 1905, due to certain arrangements in the chemical markets with which this review has no concern. It is, however, interesting to note that the flood of foreign arsenic at low prices which overwhelmed the Devon and Cornwall industry a few years ago has been stayed, and that the home producers are by no means so hopelessly out of it as had been predicted. Much the same remark may be passed with regard to barytes, which now claims our notice, though the increase of the output from 29,063 tons to 35,745 tons has not been accompanied by any rise in price. The bulk of the increase has to be attributed to the New Brancepeth mine, Durham, a locality probably best known to the bulk of our readers in connection with coke. This mine, with its 7199 tons, is now the largest producer of barytes—that is, the ordinary sulphate—though as regards the carbonate, the Settlingstones mine, Northumberland, with its 8253 tons, heads the list.

Passing on to copper, there is not much of interest to dwell upon, the developments in the branch not being up to expectation. The output of ore rose from 6903 tons in 1905 to 7478 tons, and the values from £21,796 to £26,466, this apart from the copper precipitate obtained in Anglesea. The Levant mine in Cornwall is still the largest producer, though it shows a somewhat serious falling off compared with 1905, while the Ramsley mine at Okehampton comes a good second in values. Now-a-days, of course, the silver and gold contents of a copper property are closely concerned with its prosperity, and the figures given in the returns must not be read as if they related to copper alone. The small mine at Richmond, Yorkshire, shows an output of 341 tons of ore, a decided increase on the previous year, and the partially developed property at Killeen, Tipperary, can be referred to in similar terms. Wales does not appear at all as a copper ore producer in 1906, but the Dolgelly mine, where an Elmore plant has been installed, and a new mine now producing in Cardiganshire, should alter this in the 1907 returns. This, of course, refers to copper ore mining. With regard to precipitate, the output from the old Anglesea mines, stimulated, no doubt, by the high price of the metal, shows a value of £12,800 compared with £3780 in 1904.

The production of fluor spar, which has come so prominently into demand in late years as a metallurgical flux, shows only a slight increase over 1905, though compared with only a few years ago the output of 41,849 tons is a sufficiently startling figure. Derbyshire has now got well to the fore as regards this mineral, though the output from Durham, chiefly from the mines of the Weardale Lead Company, has increased. None is obtained at present elsewhere than in these two counties. Though the bulk of the Derbyshire output is represented as coming from mines, it is not so much actual mining which is taking place as the working of old mining dumps, where the fluor spar has long laid as the *débris* from lead mining. With regard to iron ore, the output rose by almost one million tons, the figure 15 million odd tons, being higher than in any year since 1884. The new drainage operations recently started in the Furness district should lead to an increased home production and correspondingly lessened imports, but this is rather a matter for future comment. Compared with England, the Welsh iron ore production is quite insignificant, but we may say that the decreased production of the Coed Llan hematite mine at Bodfari, in Flintshire, is due to the active prosecution of development work, which is confidently anticipated to result in the opening up of large bodies of ore. Our imports of iron ore amounted to close on 8 million tons, an increase of half a million on the preceding year, of which nearly 6 million tons came from Spain, the rest coming principally from Greece, Norway, Algeria, Sweden, and France, in the order named. So far the influence of the Dunderland Company has not made itself severely felt by the Spanish exporters, and apparently the latter still have breathing time. For some time Portugal has shown declining exports to this country, and now disappears from the list, in company with Newfoundland. With regard to lead ore, it hardly needs emphasis that the high prices ruling during the last two years for the metal have brought prosperity to the mining industry. Though the total production of 30,795 tons of dressed ore in 1906 was only about 3000 tons over that of 1905, the value rose from £244,752 to £341,405.

Although values are now falling, we may expect still more satisfactory returns from this year's working, especially from Flintshire, where the Rhosesmor mine is doing exceedingly well, and the North Hendre, with its new pumping engine, shows every prospect of again paying substantial dividends. The most noteworthy individual output of ore is from the Van mine, Montgomeryshire, which doubled its previous year's figures in 1906. This feat will be emulated during the current year, if we are not greatly mistaken, by the Wiregill Deep mine in Teesdale. The present returns from this mine, by the way, and the fact that electrical pumping machinery is now being installed preparatory to extensive developments, presage a future for Teesdale mining of a brighter hue than was predicted of it when the London Lead Company abandoned the district four or five years ago. Before passing on from lead, a word must be said about the somewhat extraordinary assay figures given for some of the Flintshire ores. The chief complaint about the dry assay of lead ore, from the mineowners' point of view, is that it is usually too low; but in the case of some of the smaller Flintshire mines we have figures far above the theoretical, in one case 90 per cent., and in another 91 per cent. It is noticeable that these remarkable results are only obtainable in Flintshire, and envious mineowners in other districts are anxious to learn how to dress galena up to this standard. Manganese ore shows a considerable increase, the figure being 22,712 tons, against 14,474 in 1905. The North Wales Iron and Manganese Company is chiefly responsible for this increase, the output of the British Manganese Company having decreased considerably; this, it should be mentioned, is due to a stoppage of work from causes quite unconnected with the ore supply. The ore is, of course, of much lower grade and value than the oxide formerly obtained in Devonshire, but it finds a ready sale, and there is no reason to suppose that the manganese mining industry of Carnarvonshire will prove of mushroom vitality. With regard to tin, there is not much in the 1906 returns to testify to the expansion of the mining industry, the output of black tin showing a slight decrease from 7201 tons to 7153 tons, though the values were considerably higher. It will be some years, of course, before the various developments now in progress make a material effect upon the statistics of production.

Wolfram ore continues to be obtained in increasing quantities in Cornwall by the aid of magnetic separation, East, Pool and Agar United and Clitters United mines being the principal contributors to the total of 271 tons. Coming now finally to zinc, we note a reduction in the output of blende from 23,909 tons to 22,824, though, as in the case of some other metals, the values were higher. The order of merit as regards production is the same as in the two previous years, viz., Nenthead, in Cumberland; Carshield, Northumberland; and Minera, Wrexham. All these mines, however, had decreased yields compared with 1905, Nenthead showing up the worst in this respect. In Flintshire the Halkyn mine had a slight increase, while the Milwr, which promised so well, shows a serious decrease. In Cardiganshire the Castell mine at Ponterwyd is the only one to show an increase. In this district some of the lodes contain so much iron pyrites that a good deal of blende is rendered unsaleable, water concentration not being effective in separating the mineral. Trials, however, which have been made on the large scale with Dawes' magnetic separator at one of the mines portend an early solution of a troublesome problem. To make one more captious remark before concluding, may we suggest that it would be more correct at the present day to designate the mine near the Devil's Bridge as the Rheidol mine instead of the Ystumtuan.

THE GERMAN INSTITUTION OF NAVAL ARCHITECTS.

No. I.

THE ninth year's meetings of the Schiffbautechnische Gesellschaft began on the 25th inst. in the hall of the Königliche Technische Hochschule zu Berlin, in Charlottenburg, under the presidency of the Grand Duke Friedrich August of Oldenburg.

The proceedings were opened with the despatch of a telegram to the Emperor in respectful recognition of the acceptation by him of the first gold medal of the society.

The first paper, which treated of "High-speed Motor Boats,"* was read by Dr. M. Bauer, naval architect, of Berlin. The author dealt chiefly with the question of the use of combustion motors with high speeds of revolution, which it is contended is one of very considerable interest, not only to designers of motor boats and boat motors, but also to those of large vessels. This is the case especially in view of the endeavours which are being directed towards the introduction of turbines with high speeds of revolution, which, apart from certain technical difficulties, are the subject of considerable differences of opinion both among engineers and among shipowners. These points of contention, which urgently require to be cleared up, relate chiefly to the advantages and disadvantages of screw propellers rotating at high speeds. The author of the paper makes a general review of the question as to the connection existing between the revolutions per minute of the propeller, the loss of work in the latter, and the possible reduction in weight of the engines and boilers, and discusses the corresponding conditions of the high-speed motor boats looked upon as an extreme application of high-speed motors generally.

In general, it appears that the weight of a motor depends on the cubic content of its cylinder, which is the smaller, the greater the number of revolutions per minute attained. This reduction of cubic content has its practical limits, especially in the case of gas engines, where the sizes of valves then required gradually become unmanageably large. It is shown by means of curves that as the thrust of a propeller increases, the efficiency of the latter first augments, and then at a later stage diminishes, but that the decrease is by no means in proportion to the accompanying increase of the slip, as is often assumed.

A diagram is given, the abscissæ of which are values of the expression:

$$\frac{\text{Work of rotation expressed in H.P.}}{(\text{Speed of propeller with ref. to water})^3 \times (\text{dia. of propeller})^5}$$

and whose ordinates give curves of propeller efficiency, pitch, and slip respectively. From these it appears that, as the value of the above expression increases, the slip increases at first rapidly, and then more slowly up to percentages of about 45 to 50, and that the efficiency decreases in a curve which gradually becomes less steep until it reaches percentage values lying between 50 and 55 at the upper limit of the diagram.

In order to illustrate the efficiency of the propeller for different speeds of revolution another diagram is given, the abscissæ of which represent successively increasing horse-powers of the motor, while the ordinates give curves of efficiencies of the propeller when running at 600, 800, and 1000 revolutions respectively in a vessel of 10 knots speed, and a similar curve for 800 revolutions and 20 knots speed. The efficiencies, beginning at 80 per cent., at first fall rapidly, and then more slowly.

Of the three efficiency curves first mentioned, that for 600 revolutions falls to 50 per cent., that for 800 revolutions to 35 per cent., and that for 1000 revolutions to an imaginary 16 per cent. opposite the highest horse-power given, while the curve for 800 revolutions and 20 knots falls only to 72 per cent. at the same point.

Stress is laid on the point that in order to attain great speeds the masses to be moved must be kept small. There is now a tendency to reduce the weight of the motive machinery, and the probability of further reductions in the near future, to be obtained by the substitution for the present engines of motors on other systems, is pointed to.

Work done, which engineers measure by the horse-power, increases in all motors with the revolutions per minute of the shafting, and with the increase of the working pressure—in steam and combustion motors—or of the voltage—in the case of electro-motors. As a consequence the light motors always work with high speeds of revolution and high internal pressures.

High speeds of revolution of the propeller, which latter is almost always connected directly with the shaft of the motor, do not always cause great losses of propulsive effect—*i.e.*, low efficiencies. Again, a low efficiency of the propeller is not always tantamount to a low efficiency of the whole vessel. For certain fixed relations between given dimensions of vessel, work of motor, and speed of steaming, the propeller will show only good efficiencies, while under other sets of conditions it will show only moderate or bad results, and this in spite of excellent work from a technical point of view, and whatever the speed of the propeller may be. The deciding factor in this case is the proportion borne by the peripheral to the axial velocity of the propeller.

The effects of an alteration in the weight of the whole vessel—particularly of that of the engines—and of the alteration of the efficiency of the propeller on the speed of the ship or boat are of a totally different kind. The increase of weight may increase the resistance offered by the water and by the air to the propulsion of the vessel and improve the efficiency of the propeller—by a decrease in the revolutions—to such a degree that the speed will become greater. After the increase of weight has reached a certain point, however, the resistance increases faster than the efficiency of the propeller, and the speed of the vessel will then be diminished. On the other hand, the effect on the resistance of a reduction of the weight may be such that, in spite of the diminution in the efficiency of the propeller, a given speed of vessel may be maintained, or, under certain conditions, even increased.

Meanwhile, conditions which show good results on paper cannot always be realised in practice, because consideration has to be given to questions of design and construction, which again are influenced by the purpose for which the vessel is intended and by the costs of construction and of working.

The foregoing considerations are also illustrated by diagrams, which cannot, however, be reproduced here.

The following list is given of the dimensions and speeds of some of the fastest boats hitherto built:—

Name of boat.	Length. ft.	in.	Horse-power of motor.	Speed over long distance in knots.
Knirps	16	5	13	11·40
Bleipner	24	7	20	15·00
La Rapée II.	26	3	28	16·00
Argus II.	24	9	45	18·00
La Rapée III.	25	11	45	18·40
Titan II.	25	11	54	19·02
Blitzmädel	39	4	90	23·00
La Rapière	26	3	120	24·90
Antoinette IV.	26	3	150	25·00
Mercédès Charley	39	4	180	26·00
Panhard Tellier	39	4	210	28·00

For the working of high-speed motor boats only steam and oil motors—as internal combustion motors for benzine, petroleum, &c., are shortly designated—appear suited, since electric machinery—even that on the "combined" system—weighs twice or three times as much per H.P. The weights per H.P. of steam and oil machinery of equal power are alike so long as the speed of revolution is kept constant. Since these, however, can, without difficulty in construction or in working, be considerably higher in the oil than in the steam motors, much lighter engines on the former principle can without hesitation be adopted, so long as the losses due to the high speed of revolution of the propeller are made up for by advantages in another direction.

The utilisation of the energy present in the fuel is twice or three times as good in the oil as in the steam

* "Schnellaufende Motorboote."

motor, and the adoption of the former engine accordingly gives a considerable saving in weight of fuel to be carried. The space required for the installation of, and attendance on, the oil motor is about half as great as that of the steam motor, and, consequently, when the former is made use of, the engine-room becomes smaller, and the spaces for general purposes roomier. The disadvantages at present attaching to the oil motor, as compared with the steam motor, are to such a degree outweighed by its advantages, that it must now be looked upon as the engine *par excellence* for light high speed boats.

The advantages possessed by the high speed motor boats render them especially well adapted for naval purposes. Their light weight, and their constant state of readiness for work, are such that they have already made their way into all the larger navies as launches for the larger vessels. With improvements in the motors the range of their application may with certainty be expected to extend. Since the defects now attaching to large motors are such as may by suitable design be gradually lessened, the oil motor may, within the next few years, be confidently expected to supersede the steam engine in all cases in which the conditions of the case are in its favour.

VANADIUM STEEL IN THE UNITED STATES.

SEVERAL interesting experiments and developments in the manufacture and use of vanadium steel have been made in the United States. The American Vanadium Company has developed five grades of steel, the character of which is shown in the accompanying Table No. I. These are kept as free as possible from sulphur and phosphorus. Sulphur may be as high as 0·035 per cent. With phosphorus up to 0·02 per cent., the silicon may be as high as 0·10 per cent. in the first three and 0·15 per cent. in the fourth grade. With phosphorus as high as 0·03 per cent. the silicon should not exceed 0·05 to 0·06 per cent. in the first three grades or 0·10 per cent. in the fourth.

TABLE I.

	No. 1.	No. 2.	No 3.	No. 4.	No. 5.
	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
Carbon ..	0·25 to 0·39	0·20	0·24	0·45 to 0·55	0·12 to 0·15
Vanadium ..	0·16 to 0·18	0·12	0·16	0·18	0·12
Manganese ..	0·40 to 0·50	0·30 to 0·40	0·40	0·80 to 1·10	0·20
Chromium ..	1·00	0·50	0·80	1·25	0·30

With steel No. 1 three methods of heat treatment were employed:—First, annealing at 800 deg. Centigrade for one or two hours, and then cooling in air or ashes according to the character of the work; secondly, quenching from 900 deg. Centigrade in lard or fish oil, and then annealing for from one and a-half to two hours; thirdly, quenching from 950 deg. in lard oil and letting down at 360 deg. for 15 to 30 minutes in a lead bath, and then cooling in air. This grade of steel treated by the first process is suitable for light axles, connecting and coupling-rods, driving axles, and piston-rods. If treated by the second process it is employed for crank shafts, crank pins, transmission parts, and gear wheels. Steel No. 2 requires no special heat treatment and is intended for axles, rods, and parts in which strength to resist torsion is of importance; it is also used for large machine bolts. Steel No. 3, which also requires no special heat treatment, is suitable for axles, rods and bolts. Steel No. 4 may be subjected to the following heat treatment:—First, annealing at 800 deg. Centigrade for one hour, and cooling slowly down to 600 deg., care being taken not to chill the steel by too rapid reduction of temperature. With this treatment the steel is suitable for solid-centre railway carriage and wagon whee's, crank pins, and gun barrels. Secondly, quenching in oil from 900 deg. Centigrade, and drawing back at 450 deg. in a lead bath, then cooling in air. With this treatment the steel is adapted to springs for locomotives, automobiles and carriages. Steel No. 5 is subjected to the ordinary case-hardening process, and is used for ordinary machine and engine parts. The results of tests of ordinary "carbon" steel, nickel steel, and vanadium steels of a grade adapted for automobile work resulted as in Table No. II.

TABLE II.—*Tests of Steels.*

—	Axle steel.	Ni kel axle steel.	Vanadium steel No. 1 with heat treatment.		
			No. 1.	No. 2.	No. 3.
Yield point, lb. per sq. in. ..	41,800	49,270	63,570	110,100	224,000
Ult. strength, lb. per sq. in. ..	65,840	87,360	90,080	127,800	232,750
Ratio, per cent.	62	56	66	87	96
Elongation in 2in., per cent.	42	34	33	20	11
Contraction of area, per cent.	61	58	61	58	39
Torsional twists	2·6	3·2	4·2	2·5	1·8
Alternating bends	10	12	18	10	5
Pendulum impact, ft.-lb. .	12·3	14	16¼	12	6
Alternating impact, number of strokes	960	800	2,700	1,850	800
Falling weight on notched bar, number of blows	25	35	69	76	—
Rotary vibrations, number of revolutions	6,200	10,000	67,500	—	—

Cast steel frames for locomotives have been made with vanadium steel by the Union Steel Castings Company. Five frames were made from one heat for four, six, and eight-coupled engines, the weight of each frame being from 4400 lb. to 5800 lb. The steel poured quietly, and the frames were finished satisfactorily. It was stated that this heat was the best ever made, and it is considered that the use of vanadium will result in producing castings more nearly perfect and solid than those of ordinary carbon steel. It is not detrimental to the quality of the steel with regard to resistance to static strains, while the vanadium steel is decidedly superior to ordinary steel when dynamic stresses have to be re isted. The company has issued a statement relative to its experience. From this we abstract the following:—

"We form test bars of 8in. with ½in. connection. To detach one of these test bars from an ordinary steel frame requires from six to twelve blows with a 10 lb. sledge. Test bars on a frame made of vanadium steel required from 100 to 150 blows by the same man with the same sized sledge. The fracture of vanadium steel is closer and presents a much tougher appearance than ordinary steel. Two samples were tested in a vibratory machine deflecting a bar 7in. in length and ⅝in. diameter, ½in. on each side of the centre, making 1in. deflection. The average number of vibrations required to break a bar of ordinary steel was 4206, while the average number of vibrations required to break a bar of vanadium steel was 12,776.

"We also bent a sample of ordinary steel and one of vanadium steel to an angle of 90 deg., and reversed them by bending in the opposite direction to an angle of 90 deg. The ordinary steel bent three and one-half times before breaking, and the vanadium bent four and one-half times In bending a ½in. by 1in. test bar of vanadium steel on a single bend under a hammer, it was bent flat on itself without fracturing or shearing. A similar sample of ordinary steel of same analysis, except as to vanadium, also bent flat on itself but sheared slightly.

"If the carbon were increased in the ordinary steel so as to give a tensile strength of 77,800 lb., it would give almost, but not quite, as good results in elongation and reduction as vanadium steel. The elastic limit, however, would probably fall about 5000 lb. below that obtained with the vanadium steel. In view of the fact that the bending bars of vanadium steel were over 77,000 lb. in tensile strength, while those of ordinary steel were slightly over 68,000 lb. in tensile strength, we come to the conclusion that the results obtained indicate that the vanadium steel is very much tougher than the ordinary steel. If ordinary carbon steel of 77,000 lb. tensile strength or over had been used in making the bending and vibratory tests, the results would have been very much inferior to those obtained from the lower carbon steel."

In planing the vanadium steel frames, the tool was made to take the same cut as with ordinary cast steel frames. The metal was found to be harder and tougher and more difficult to cut, but not sufficiently to affect the time of machining. The chips of vanadium steel were much larger, tougher, and more regular than those from ordinary steel.

In a welding test, two pieces were welded together and then planed to a section ½in. by 1in. for the testing machine. The fracture indicated that the weld was not quite perfect on one side, and it left a slight fin. The bar did not break, however, until a pull of 72,460 lb. had been reached.

TINNING OF METALS.

A REPORT of considerable length has recently been issued on dangerous and injurious processes in the coating of metal with lead, or a mixture of lead and tin. It has been compiled by Miss A. M. Anderson, his Majesty's principal Lady Inspector of Factories, and T. M. Legge, M.D., his Majesty's Medical Inspector of Factories. The report also contains the results of an experimental investigation into the conditions of operating tinning workshops, which has been written by G. E. Duckering, one of his Majesty's Inspectors of Factories, who carried out the investigation.

The first portion of the report is devoted to questions referred to for inquiry and report, technical terms, processes and their purposes, and other questions relating to the subject. One of the most striking and important points mentioned in the early part of the report is that in the manufacture of terne plate, which is carried out in a few works in South Wales, it has been found that there has been no sign of lead absorption among any of the workpeople employed. On the other hand, it is well known that among workers in the tinning of hollow-ware the absorption of lead, and consequently lead poisoning, is widespread. The investigators visited six works where the former process was in operation, and Dr. Legge examined forty-four persons engaged in the work without finding signs of lead absorption in any of them. At first this result seemed difficult to explain. Upon inquiry, however, it was found in practice that great care is taken to remove all trace of acid before immersing the iron sheets into the flux. The immersion of sheets in the "pickling" acid takes place outside the tinning shop, and the sheets are then brought and placed in one or two baths of clean water in the tinning shop before insertion into the flux-covered portion of the metal bath. Care has to be taken by the tinman that each sheet is completely wet with water before insertion into the flux-covered metal. The least speck of dry part on a sheet will cause explosive action. In consequence there is in terne plate making no acid to combine with the lead, and fumes from the molten metal at the parts where it is liable to disturbance are hindered by the layers of flux, palm oil, or resin. Surfaces around and near to the bath are generally moist from the dripping of the plates, so that diffusion of dust is not liable to take place.

The differences in the procedure in terne plate making and the tinning of hollow-ware are clearly set forth, and the conclusions arrived at are interesting. The absence of lead poisoning among terne plate tinners is attributed to four causes:—(1) The use of cleaning agents and flux of such nature and in such a way as to involve a minimum contact with the tinning metals, and under such conditions as to inhibit extensive interactions between them, and also under such conditions as to inhibit production of fumes or vapours, even if any interaction occurs. (2) The use of a scientifically prepared flux containing no uncombined acid or excess of water in such a way as to prevent introduction of these substances or of ferrous compounds into intimate contact with the tinning metal. (3) So conducting the operation of tinning that any chlorides possibly adhering to the plates are removed before the plate reappears in the open air, under conditions preventing them from appearing in the air as vapour. (4) The absence of any manual work on the plates before the metallic coating is set and hard.

The existence of widespread lead poisoning in the tinning of hollow-ware is also attributed to four causes:—(1) The use of cleaning agents and flux in such a way as to bring these materials into intimate contact with the tinning metals under conditions eminently favourable for chemical interaction and vaporisation of resultant compounds. (2) The use of unscientifically prepared flux containing a large excess of water and much free acid. (3) So conducting the operations as to favour the escape into the atmosphere of vapours of soluble lead compounds and of metallic lead and soluble lead compounds, carried mechanically by fibre during processes subsequent to actual tinning, wiping, &c. (4) The possibility of contamination of the hands by soluble lead compounds due to manipulating the material with which the articles are wiped.

It is pointed out that while the use of a scientifically prepared flux in hollow-ware tinning would no doubt lessen the possibility of the production of fumes, it is not to be anticipated, unless a flux containing no chlorides were used, that this would do away with lead poisoning, but the method of use is a far more important factor.

In the tinning of hollow-ware the severity of the poisoning attacks exceeds that noted in any other of the tinning processes, and greatly exceeds that of the total lead poisoning cases for the years 1901 to 1904. The proportion of slight cases among men, 10·7 per cent. is said to be without example in any lead industry. Third attacks of chronic plumbism among female workers in the tinning of hollow-ware is nearly five times as frequent as among females employed in lead industries taken as a whole. Another point worthy of mention is that it has been found that the wiping off exposes the workers to greater risk than the tinning process.

The suggested regulations set forth in the report do not apply to the processes in the manufacture of terne plates, nor do they apply to processes in which no lead is employed. These suggested regulations, which are twelve in number, apply to the coating of metal articles with lead or a mixture of lead and tin by any process in which chlorides are used.

The following are some of the most important of these regulations:—No lead shall be used in the tinning of metal hollow-ware; no female person shall be employed in dipping or wiping; dipping shall not be carried out unless the tinning bath is so enclosed and provided with exhaust draught as to prevent the fumes from entering the workroom. The skimmings from the tinning bath and dust and *débris* collected from the floor shall be deposited in a suitable receptacle especially provided for the purpose in connection with an exhaust draught; a health register containing the names of all persons employed shall be kept in a form approved by the Chief Inspector of Factories, and every person shall be periodically examined by the surgeon. Other regulations refer to the clothing of the workpeople, the equipment of lavatories, &c.

INTERNATIONAL ELECTRO-TECHNICAL COMMISSION.

THE preliminary meeting of the International Electro-technical Commission was held in London in June, 1906, and delegates from some fourteen countries were present at it. The Right Hon. Lord Kelvin was elected the first president and Colonel R. E. Crompton, C.B., honorary secretary of the Commission. A set of proposed rules relating to the general organisation of the Commission was drawn up and adopted, subject to ratification by the authorities who had appointed the delegates. These rules have, we are informed, been practically accepted by all countries, and there is, therefore, little doubt of their being finally adopted at the first meeting of the Council, which, we understand, is likely to be held next summer. Broadly speaking, the rules are based upon all countries being on an equal footing, with equal taxation and equal voting power; they also provide for the manner in which the recommendations are to be arrived at, and place the affairs of the Commission and the method of carrying out its objects in the hands of a Representative Council, consisting of the president of the Commission, the presidents of the local committees, who are vice-presidents of the Commission *ex officio*, one delegate from each of the local committees, and the honorary secretary.

The general objects of the Commission are set forth in the following resolution, adopted by the Chamber of Government Delegates at the Electrical Congress held at St. Louis in September, 1904:—"That steps should be taken to secure the co-operation of the technical societies of the world by the appointment of a representative Commission to consider the question of the standardisation of the nomenclature and ratings of electrical apparatus and machinery." We understand that up to the present time local committees have been appointed in Austria, Belgium, Denmark, England, France, Germany, Hungary, Mexico, Sweden, and the United States, and that the question of appointing a local committee is also being considered in Australia, Canada, Japan, New Zealand, Russia, South Africa, and Switzerland.

From the commencement the Institution of Electrical Engineers (Great Britain) has taken a very prominent part in the matter, and not only have they defrayed the preliminary expenses, but have most generously granted a substantial loan to the Commission in order that no financial difficulties should hamper the work of organisation during the first year, which action has been much appreciated by all concerned. The success with which the movement is meeting on all sides will not, however, necessitate any great inroads being made into the funds placed at the disposal of the honorary secretary by the Council of the Institution.

At the end of last year the British Local Committee appointed a sub-committee on Nomenclature, under the chairmanship of Mr. A. P. Trotter, the Electrical Adviser to the Board of Trade. This sub-committee are now engaged in drawing up a list of terms, with their explanations, in general use in the electrical industry, and the Council of the Commission, we understand, will most probably publish a glossary of electro-technical terms in French and English, the languages in which it has been decided all reports of the Commission are to be published. Under nomenclature is to be included the question of symbols, which will be taken up at a future date. When the local committees in the different countries have settled down to work, the British Local Committee, we understand, will appoint a sub-committee on Electrical Machinery and Apparatus to consider in particular what matters can be brought to the notice of the Commission with a view to possible international agreement. The British Local Committee are working in conjunction with the local committees of those countries taking part in the labours of the Commission, and the secretaries of the local committees are kept *au courant* through the medium of the central office now established in London at 28, Victoria-street, Westminster, the secretarial work being in charge of Mr. C. le Maistre, A.M. Inst. C.E., the acting secretary to the Commission, to whom all inquiries should be addressed.

INSTITUTE OF SANITARY ENGINEERS.—On and after Monday, December 16th, the address of the Institute of Sanitary Engineers will be 120 and 122, Victoria-street, Westminster, S.W.; the telephone No. 3017 Victoria; and the telegraphic addre s Sangineers, London.

INSTITUTION OF CIVIL ENGINEERS: GLASGOW STUDENTS.—At the second general meeting of the Glasgow Association of Students of the Institution of Civil Engineers, held in the Institution Rooms, Bath-street, Glasgow, on the 25th inst., a paper on the "Construction of Macadamised Roads Suitable for Modern Traffic" was read by Mr. Thomas Aitken, M. Inst. C.E. The paper dealt with foundations, road stones, binding and rolling, and the question of treating roads to overcome the dust and mud difficulty. The author said that tarring the road stones in some form would be an important factor in the future methods of constructing highways in this country. Various methods used for applying the tar were referred to, and the author showed that some form of mechanical apparatus was necessary to treat the road stones properly after being spread. For really successful treatment surface pressure was, he said, necessary before proper pene'r ation of any matrix could take place.

THE POWER PLANT AT NECAXA, MEXICO.

(By our own Correspondent.)

No. II.*

In my former account of the enterprise of the Canadian Company, which has made so extensive an initiation in harnessing up this part of Mexico's fine natural water-power resources, I have shown how by adapting the most modern resources by closely surveying and studying the district and diverting streams into one favourable watershed, the company's engineers have secured a steady and reliable output of upwards of 200,000 horse-power.

The stream used—the Necaxa River—was small, and its development marks a record of achievement in many directions, among which may be mentioned:—

(1) It is the first large example of the really profitable use of large store reservoirs for water-power development. What is done at Necaxa is a long way ahead of the usual practice of merely storing enough water to bridge over the peak hours of the day with the surplus of the slack hours, at the head generating station, and for the first time it demonstrates that where large heads of water are to be utilised, the question of storage reservoirs is a very important and remunerative one.

(2) The next point in which it is a record is the extreme care which is taken by complete duplication at every point, and of every service, to provide against accident at its chief objective—Mexico City—while in Mexico City there is a steam reserve in various power stations taken over and retained by the company of over 20,000 horse-power, and there is a second local water-power scheme of 5000 horse-power, besides all the usual stand-bys in different methods, which will be described later on.

(3) The various features of the works which peculiar local conditions dictate have introduced many novelties. Of these, the most striking is the great advantage in cost and strength of construction which has been secured by working on the hydraulic fill system. Had it not been for the aid of this system the scheme of storing so much water for power purposes would hardly have been the marked success which it is proving, in spite of the peculiar advantage of the great head—4500ft.—which is available for the greater part of the stored water.

(4) The use of excessively high-water pressures and impulse turbines—commonly known as "Pelton wheels"—set on vertical shafts, with Escher Wyss and Co.'s nozzle contracting governors. Pressures of 1450ft. are being used, and 2100ft. will be the operating head at the second station.

(5) The transmission of power to distances not heretofore attempted at voltages from 40,000 to 60,000, and with a loss of only 20 per cent., reducible when completed to about 12 per cent.

In connection with such a plant, so full of pioneer work, as one would expect, a large number of engineers have been employed, and almost every feature presents much of novelty. Equally, when so much money, and such vast interests are at stake—Mexican industrial development depending in no small degree upon the success of this enterprise—the work is being carried out in the most careful and deliberate manner.

The chief engineer to the works has been Dr. F. S. Pearson, M. Am. Soc. C.E., with whom have been associated Messrs. F. O. Blackwell and James D. Schuyler, M. Am. Soc. C.E., while the work is under Messrs. Albert Carr and Hyde, with Mr. R. F. Hayward as general manager, and a large staff of most energetic and able assistants.

The rather unusual precaution of duplicating the standpipe has been adopted. The standpipes are placed side by side, and are each 8ft. in diameter, and 3ft. apart, protected by a masonry tower 66ft. by 25ft. on plan and 161ft. high from floor to working platform above. This platform is 17ft. 1½in. above top-water level.

Each standpipe contains five outlet gates, each 5ft. 6in. in diameter, so arranged that it should never be necessary to open any gate under a greater pressure than 26ft. head. The gates are set at an angle of 60 deg. to the horizontal, and are lifted by a plain chain and windlass arrangement, the more scientific gearing usual in the Old World being less suited to the circumstances here. Before each gate large screening chambers—see Fig. 13—have been provided.

The outlet from the standpipes is by two 8ft. diameter pipe lines ⅜in. thick, well riveted and supported on concrete piers through the Necaxa tunnel—1550ft. in rock—to a point of discharge for scour or stormwater into the Necaxa River bed below the dam. Here sluice gates discharging into the river have been provided, and from this point onward the pipes are reduced to 6ft. in diameter for a distance of 2200ft., 800ft. of which is in tunnel. At the end of this length the pipes are both connected up to a large receiver, 22ft. long, 7ft. diameter, which acts as a header, fair across the line of pipes—receiving the delivery from these two, 6ft. diameter pipes, and delivering to six pipes each of 30in. diameter, from which the Pelton wheels are supplied. These six pipes are carried down at a grade of 41 deg. through two parallel tunnels, 1900ft. long, the last 560ft. of this section, which is 2460ft. long, is in the open air firmly set in concrete channels. All pipes are carried, as mentioned above, by concrete piers.

Before reaching the header the large 6ft. pipes are controlled by valves. Each of the smaller pipes is controlled by a valve, and the valves are relieved by by-pass valves. This detail of the works looks complicated enough, since the sets of pipes are cross connected, and also water is taken off at this place to work the Pelton wheels which drive the air-compressors, by which the cable hoists for the transport of materials is worked, and also to work the hydraulic pressure plant. All valves are operated by hydraulic pressure. Immediately where they leave the header the six 30in. drive pipes are each fitted with a 30in. air-relief pipe which is carried up 315ft. to the top of the hill over the tunnel, where it is open to the air at an elevation above top water level in the dam.

The header and these six air relief pipes are situated immediately beyond the knoll which hides the pipe lines on the right-hand side of the view in Fig. 9. At that side, just beyond the bridge across the river, can be seen the derrick which carries the wire-rope cable hoist for communication with the first power-house. This cable hoist carries loads up to 15 tons, and in addition to the ground lines between the two falls, operates two aërial lifts about 350ft. and 750ft. each, at an angle of nearly 70 deg. with the horizontal. The river at these places takes the two remarkable leaps mentioned before, namely, the "Salto Chico"—small leap—and the "Salto Grande"—great leap. These falls occur in the part of the river between the header of the drive pipes and the power-house, and the total fall from this part of the route is 1200ft.

All the pipes are of mild steel lap-welded. The joints are flanged over and clamped together. The necessary stiffening is obtained by external angle rings. The usual length of each section is 30ft. The external diameter of the drive pipes is 30⅜in., and the internal diameter diminishes as the water-head increases, so that near the Pelton wheels it is only 29in. The static head at the power-house, beside the wheels, is 1452ft., reservoir full; friction and other losses, however, reduce this to a working head of from 1200ft. to 1300ft.

The manufacturers of the pipes were the Actien Gesellschaft Ferrum, of Kottowitz, Germany, and before leaving the works the test pressure was 1¾ times the maximum calculated pressure.

As has been repeatedly mentioned, no precaution usually taken has been neglected. On the large pipes expansion joints of the diaphragm type are provided, while on the 30in drive pipes rubber packed slip joints are used. All of these lines are everywhere thoroughly accessible, and the tunnels containing them are exceptionally roomy and well lighted by electricity.

When under full load the velocity of the water in the large pipe line is 7·5ft., and in the smaller (30in.) 15ft. per second. Under occasional overload conditions this increases to 8·8ft. and 18ft. per second respectively. At all angles the pipes are practically bedded, except at the joints, in concrete, and are very thoroughly anchored against centrifugal movement.

In addition to the nozzle contraction regulation, there is also an automatic by-pass, so arranged that it will close slowly after opening, and no racking or trouble has ever been experienced in the pipe lines due to the speed regulation, nor, in fact, from any other cause. To guard against accident, the large 7ft. diameter header is divided by a sluice gate in the middle, so that three of the 30in. drive pipes can be operated absolutely independently of the other half; and, as already mentioned, cross-over connections and *per contra* disconnections are also provided.

The description of the turbine plant, supplied by Dr. Pearson, of New York, to the American Society of Civil Engineers last January, reads as follows (after describing the power-house):—"*Hydraulic apparatus.*—The pipe lines pass into the basement of the building, and terminate in 28in. valves operated by hydraulic power. Each of the six impulse wheels is rated at 7000 H.P., with a maximum capacity of 9000 H.P., making it possible to supply a peak load of 50,000 H.P. from the station. The wheels are of 100in. pitch diameter, run at 300 revolutions per minute, and have solid cast steel centre discs, to which are clamped 24 steel brackets." "Each" (drive pipe) "has two square 4½in. regulating nozzles fixed on opposite sides of the wheel, but joined together so that they are opened and closed simultaneously."

The shafts of the wheels are vertical, 14in. diameter, and flanged at the bottom to take the water-wheel disc, and these drive the generator direct. The whole weight, water wheel, shaft and generator rotor, is borne by a thrust bearing 30in. diameter. The oil for this bearing, which is of the floating type, is pumped in under a pressure of 150 lb. per square inch. Each set has its own independent pump, situated under the building between the foundations and driven by its own water wheel.

The two nozzles being set in opposition, there is no thrust on the bearings. The same governor which regulates the nozzles controls the supply of oil for the thrust bearings and the operation of the by-pass.

The whole of the hydraulic apparatus and the hydraulically worked valves were manufactured and supplied by Escher, Wyss and Co., of Zurich.

Each of the six generators are of the revolving field type, at a periodicity of fifty cycles, and a potential of 4000 volts, generating the current on the three-phase system, and rated at 5000 kilowatts.

In the general view of the power-house, Fig. 11, these will be seen in process of erection. Two are completed, and a general idea of their character and convenient disposition can be obtained. On the two completed generators the steady upper bearings for the shaft will be seen situated above the armature shield. The armature has an outside diameter of about 20ft. The revolving field weighs 51,000 lb., and the shaft alone 13,500 lb. The fields are wound for 125 volts excitation, and the full rated 5000-kilowatt load is got at an 80 per cent. power factor. The field is designed so that at double the normal speed—600 revolutions per minute—there is a factor of safety of two.

The ordinary excitation is effected by two motor generator sets of 250 kilowatts each. These are driven by 4000-volt induction motors from the main units, and alternatively independent turbines.

The line pressure is 40,000 volts, and can be used later at 50,000 and 60,000 volts. To raise the 4000 volts of the generators to these line voltages, five banks of 2000 kilowatt single phase transformers are employed. These are placed on a gallery parallel to the generator, and under the same open roof. Great trouble has been taken to keep everything fireproof, and the building is throughout of fireproof material. The transformers are of the oil and water-cooled type, having oil baths for insulating the coils, and for further fireproofing each is installed in its own compartment with steel bulkhead. The transformers weigh 24 tons each, and are set on wheels and rails, so as to be easily transported for repairs. The heat generated in the coils is carried away by copper cooling coils.

Incidentally in describing the generators, the water wheels, and the transformers, the main features of the power-house have been mentioned. Its situation at the foot of the Salto Grande Falls is well illustrated in Fig. 10. It stands on a massive concrete foundation beside the river bed. The foundation is about 220ft. by 100ft. on plan, and the building 200ft. by 88ft., and while ample in dimensions, and every piece of machinery is fully accessible, and so placed as to be most conveniently seen, there has been no waste of space. The oil switches are in the gallery, with the controlling switchboard in the centre, where the operator can obtain an unobstructed view of the machinery in all parts of the building. The small controlling switches for the large oil switches, with the miniature lamps which indicate their position, are mounted on a bench-board with dummy bus bars to form a wiring diagram, so that the attendant can always see how the apparatus is connected, and thus avoid mistakes. All the indicating instruments are placed on large vertical panels above the bench-board, where the instantaneous speed potential and power at which the plant is operated can be seen, and are so placed that the operator watching the dummy bus bars cannot be confused. Registering instruments which keep an automatic record of the pressures and output of the plant are placed behind the board. The switchboard and transformers were supplied by the General Electric Company, Schenectady, N.Y.

The transmission lines consist of two parallel sets of lines from the power-house to Mexico City, 95 miles; and one set of lines from Mexico City to El Oro, 75 miles further. Each set of lines consists of two three-phased circuits. The towers are carried to a uniform height of 54ft. above the surface, and are based on foundations sunk 6ft. below the surface, but the conductors, of which there are six on each set of lines, are situated 40ft. and 46ft. above the ground.

The conductors are six strand copper cables, ½in. in diameter, with hemp cores, and the copper has an ultimate strength of 60,000 lb., and an elastic limit of 40,000 lb. per square inch. It is fortunate that the precaution was taken of making conductors and towers as strong as are required to stand the severe frosts of Canada, because these are often heavily weighted with icicles. The towers which carry these sets of lines are entirely built of mild steel angles—an arrangement which, considering all the circumstances of the country—wet tropical conditions, which are exceptionally severe on timber, exceptionally broken country for a great part of the length, where long spans and straight direction mean the surest economy; and the superior immunity from accidents, fire, and the hundred-and-one contingencies of such a country—were unquestionably the most suitable.

A 14it. extension in the centre of each tower carries a galvanised steel cable with lightning arrester, and protects the line. A telephone circuit is also carried. The towers are designed to stand a horizontal strain of 1650 lb. at each insulator, or 10,000 lb. altogether. The standard distance between the supports is 500ft.; there are a few higher towers and spans up to 1500ft. It is stated that the standard towers only cost £12 each.*

One of the advantages of the long spans mentioned by Dr. Pearson is that it permits the use of larger and safer insulators. The insulators are in three parts, shipped separately, and cemented together in Mexico. They are to stand a potential of 120,000 volts. The insulating pins, and the crossheads to carry them, are of steel pipes with drop forged sockets. The diameter of the porcelain insulators is 14in.

The sub-stations at Mexico and El Oro follow the general lines of the power-house. In Mexico, at the Nonoalco Station, there are sixteen 1800-kilowatt oil transformers in separate compartments, covered by a travelling crane. Every precaution is taken to isolate the parts. The switchboard also carries an extensive low potential feeder system for the city. The step-down transformers supply current at either 1500, 3000, or 6000 volts, as may be required.

The station is 203ft. by 65ft. on plan, and, in addition, there are three other central stations, aggregating 20,000 horse-power, in Mexico, which are shut down owing to the cheaper power supplied from Necaxa. Mexico city can, without fear of challenge, claim to be the best served with electric power and lighted city of its size in the world.

Considering the cost of coal and the wealth of the country, the charge for the use of electricity is not high—24s. per month for a continuous service per horse-power, and the charge to the mines is £10 per annum for a continuous—night and day—service.

The distribution to the mining centres at El Oro and Tlalpujuhua is at 3000 and 6000 volts. The line at a short distance from Mexico, which it enters from the north-east, will be tapped by a sub-station, and distributed to the large and important districts of Pachuca and Puebla. Already there is considerable manufacturing activity in these districts; no less than forty cotton mills are eagerly waiting the cheaper power, and the aspirations of the Mexicans are that their country will shortly take its place among the great and wealthy manufacturing countries of the world. And certainly, so far as water-power facilities are concerned, this great power company has given the Republic a fair lead, which should eventuate in a wonderful spread of prosperity throughout the wide district it will serve.

It is reported that an American engineer has recently patented a device for preventing the collection of sleet upon the windows of car vestibules The method calls into play deflectors, which receive the impact of the air as the car moves ahead and cause currents of air to draw warm air from within the car body or vestibule, spreading it over the outer surface of the windows, and, thus, by means of the thin layer of air substantially parallel to the outer surface of the glass, keep it free from snow and sleet.

---

* No I. appeared November 8th.

* The cost of the two tower lines complete with the twelve cables and the 200ft. of right of way has been £2000 per mile.

HYDRO-ELECTRIC STATION AT NECAXA, MEXICO

(For description see page 536)

Fig. 9—VIEW OF OUTLET PIPES BELOW DAM No. 2

Fig. 10—THE POWER HOUSE—EXTER OR

Fig. 11—THE POWER HOUSE—INTERIOR

Fig. 12—ERECTING STANDPIPES

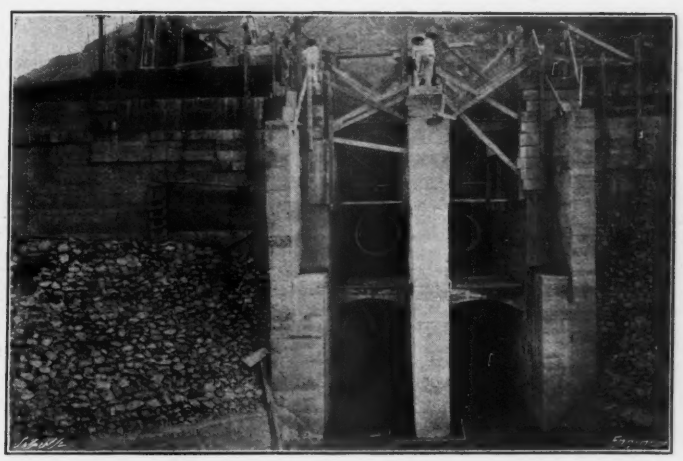


Fig. 13—OUTLET STRAINING TOWER

RIFLED ARTILLERY.

By A. G. Greenhill.

II.*—THE MOTION OF A BODY IN A MEDIUM.

In steady motion under no force of a body in a medium, a shot in the air, an air ship, or a submarine boat under water, the centre of gravity describes a helix, while the axis describes a cone round the centre of gravity, and the couple causing precession is due to the displacement of the medium.

Suppose the body weighs W lb.; in the absence of a medium the inertia is measured by W, and is the same in every direction; and under no force the centre of gravity describes a straight line, and the axis of rotation preserves its original direction, if a principal axis of the body; otherwise if the body is of revolution the axis describes a cone, right circular.

But the presence of the medium makes the effective inertia depend on the direction of motion, the external shape of the body, and on W′, the weight of fluid medium displaced.

Consider, for example, a submarine boat under water: the inertia is different for axial and broadside motion, and may be represented by

$$(1) \qquad c_1 = W + \alpha W', \; c_2 = W + \beta W',$$

where α and β are numerical factors depending on the external shape; and if the centre of gravity is moving with velocity V at an angle ϕ with the axis, so that the axial and broadside component of velocity is

$$(2) \qquad u = V \cos\phi, \; v = V \sin\phi,$$

the total momentum F in second-pounds of the medium

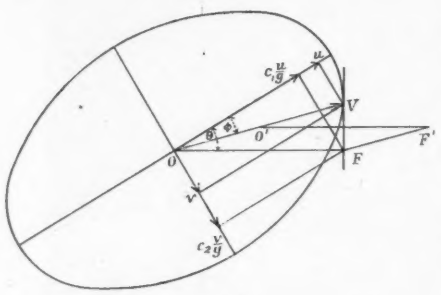


Fig. 3

and the body, represented by the vector O F at an angle θ with the axis, will have components (Fig. 3).

$$(3) \qquad F\cos\theta = c_1 \frac{u}{g} = (W + \alpha W')\frac{V}{g}\cos\phi,$$

$$F\sin\theta = c_2 \frac{v}{g} = (W + \beta W')\frac{V}{g}\sin\phi.$$

Suppose the body is kept from turning as it advances, after t seconds the centre will have moved from O to O′, where O O′ = V t; and at O′ the momentum is the same as before, but displaced from the vector O F to O′ F′.

The resultant of the components

$$W\frac{V}{g}\cos\phi \text{ and } W\frac{V}{g}\sin\phi$$

of the momentum of the body alone is

$$W\frac{V}{g} \text{ along O O′, and is unaltered.}$$

But the change of the resultant momentum F of the medium as well as of the body from the vector O F to O′ F′ requires an impulse couple, tending to increase the angle F O O′, of magnitude,

$$(4) \qquad F \,.\, O O' \sin F O O' = F V t \sin(\theta - \phi)$$

in sec.-ft.-lb., equivalent to an incessant couple

$$(5) \quad N = F V \sin(\theta - \phi)$$
$$= F V \sin\theta\cos\phi - F V \cos\theta \sin\phi$$
$$= \left(\frac{1}{c_1} - \frac{1}{c_2}\right) g F^2 \sin\theta\cos\theta$$
$$= (c_1 - c_2)\frac{V^2}{g}\sin\phi\cos\phi$$
$$= (c_2 - c_1)\frac{uv}{g} = W'(\beta - \alpha)\frac{uv}{g}$$
$$= (c_2 - c_1)\frac{u^2}{g}\tan \quad = (c_2 - c_1)\frac{c_1}{c_2}\frac{u^2}{g}\tan\theta;$$

all different expressions of the same quantity, from which to choose in the sequel.

This N is the couple in ft.-lb. changing the momentum of the medium, the momentum of the body remaining the same; the medium reacts on the body with the same couple N in the opposite way, tending when $c_2 - c_1$ and N is positive to set the body broadside to its advance.

An oblate flattened body, like a disc or plate, has $c_2 - c_1$ negative, so that the medium steers the body axially; we see this with a plate dropped in water, or a light disc or piece of paper falling in air.

But an elongated body, like a ship or submarine boat, has $c_2 - c_1$ positive, and the couple N tends to disturb the axial motion and make it unstable; this is realised easily with a stick floating on water, and pushed in the direction of its length; after a time the stick is found to be moving broadside. So, too, a steamer is always falling off its course, and requires to be steered by constant attention at the helm.

Consider a submarine boat or air ship moving freely with the direction of resultant momentum F horizontal and the axis at a slight inclination θ. With no reserve of buoyancy W′ = W, and the couple tending to increase θ has the effect of diminishing the longitudinal metacentric height by h feet, where

$$(6) \qquad W h \tan\theta = N = (c_2 - c_1)\frac{c_1}{c_2}\frac{u^2}{g}\tan\theta,$$

$$(7) \qquad h = \frac{c_2 - c_1}{W}\frac{c_1}{c_2}\frac{u^2}{g} = (\beta - \alpha)\frac{1 + \alpha}{1 + \beta}\frac{u^2}{g},$$

the metacentric height at rest being the depth of the centre of gravity of the boat below the centre of gravity of the water or air displaced; and when the speed u is enough to cancel the metacentric height, the stability is lost of axial movement without constant attention to the horizontal rudder, the boat dives to the bottom, or else breaks the surface in what is called *porpoising*—"The Diving Submarine," by R. G. Skerrett—*Journal* of the United States Artillery, reprinted in the *Journal* of the Royal Artillery, June, 1907. This loss of metacentric height due to velocity of axial advance was pointed out by Professor Jeans in the discussion on "The Stability of a Submarine," by Sir W. H. White.

An elongated shot under no control is made to preserve it axial flight through the air by giving it the spin sufficient for stability, without which it would turn broadside to its advance, in the same way as a top in made to stand upright on its point in the position of equilibrium, statically unstable, but made stable dynamically if spun with rotation enough; and the investigation proceeds on the same lines for both problems, of top and shot.

The effective angular inertia is required now of the body in the medium; denote it by C_1 about the axis of figure, and C_2 about a diameter of the mean section.

A rotation abont the axis of a figure of revolution does not set the medium in motion, so that C_1 is the moment of inertia of the body about the axis, denoted by $W k_1^2$.

But if $W k_2^2$ is the moment of inertia of the body about a mean diameter, and r the angular velocity about it, generated by an impulsive couple M, and M′ the couple required to set the medium in motion of effective radius of gyration k',

$$(8) \qquad W k_2^2 r = M - M', \; W' k'^2 r = M',$$

$$(9) \qquad (W k_2^2 + W' k'^2) r = M,$$
$$C_2 = W k_2^2 + W' k'^2 = (W + \epsilon W') k_2^2$$

putting $k'^2 = \epsilon k_2^2$, where ϵ is a numerical factor depending on the outside shape.

If the shot is spinning about its axis with angular velocity p, and the axis is precessing steadily at a rate μ about a line parallel to the resultant momentum at an angle θ, the velocity of the vector of angular momentum, is, as before for the top,

$$(10) \qquad C_1 p \mu \sin\theta - C_2 \mu^2 \sin\theta\cos\theta,$$

and equating this to g times the impressed couple

$$(11) \qquad g N = (c_2 - c_1)\frac{c_1}{c_2} u^2 \tan\theta$$

and dividing out $\sin\theta$, which, equated to zero, would imply perfect centering,

$$(12) \quad C_2 \mu^2 \cos\theta - C_1 p \mu + (c_2 - c_1)\frac{c_1}{c_2} u^2 \sec\theta = 0,$$

analogous to equation (8) in the steady motion of the top. The least admissible value of p is that which makes the roots equal of the quadratic in μ,

$$(13) \qquad \mu = \frac{1}{2}\frac{C_1}{C_2} p \sec\theta;$$

the roots would be imaginary for a smaller value of p than given by

$$(14) \qquad C_1^2 p^2 - 4 (c_2 - c_1)\frac{c_1}{c_2} C_2 u^2 = 0,$$

$$\frac{p^2}{u^2} = 4 (c_2 - c_1)\frac{c_1}{c_2}\frac{C_2}{C_1^2}.$$

If the shot is moving as if fired from a gun of calibre d inches, in which the rifling makes one turn in a pitch of n calibre or $n\,d$ inches, so that the angle of rifling δ is given by

$$(15) \qquad \tan\delta = \frac{\pi d}{n d} = \frac{\frac{1}{2} d p}{u},$$

which is the ratio of the linear velocity of surface rotation $\frac{1}{2} d p$ to u the velocity of advance,

$$(16) \quad \tan^2\delta = \frac{\pi^2}{n^2} = \frac{d^2 p^2}{4 u^2} = (c_2 - c_1)\frac{c_1}{c_2}\frac{C_2 d^2}{C_1^2}$$
$$= W'(\beta - \alpha)\frac{W + \alpha W'}{W + \beta W'}\frac{(W + W'\epsilon) k_2^2 d^2}{W^2 k_1^4}$$
$$= \frac{W'}{W}(\beta - \alpha)\frac{1 + \alpha\frac{W'}{W}}{1 + \beta\frac{W'}{W}}\left(1 + \epsilon\frac{W'}{W}\right)\frac{k_2^2 d^2}{k_1^4}.$$

For a shot in air the ratio W′/W is so small that the square may be neglected, and formula (16) can be replaced for practical purpose in artillery by

$$(17) \qquad \tan^2\delta = \frac{\pi^2}{n^2} = \frac{W'}{W}(\beta - \alpha)\frac{k_2^2 d^2}{k_1^4}.$$

If then we can calculate α, β, and $\beta - \alpha$ for the external shape of the shot, equation (17) will give the value of δ and n requisite for stability of flight in air.

The couple N, compounded with R, the resistance of the air, removes the centre of effort from O, the centre of gravity and of figure considered coincident, to a centre of effort at E on the axis in front of O, at a distance O E such that

$$(18) \qquad R \,.\, O E \,.\, \tan\theta = N,$$

or, as before, in (7) for the submarine boat,

$$(19) \qquad O E = \frac{c_2 - c_1}{R}\frac{c_1}{c_2}\frac{u^2}{g}$$

and in Bashforth's notation, putting

$$(20) \qquad R = d^2 \frac{k}{g}\left(\frac{u}{1000}\right)^2$$

$$(21) \qquad O E = \frac{c_2 - c_1}{d^2}\frac{c_1}{c_2}\frac{(1000)^2}{k}$$

and for a shot in air

$$(22) \qquad \frac{O E}{d} = \frac{W'}{d^3}(\beta - \alpha)\frac{(1000)^2}{k}$$

At a velocity of 2000 f/s, we find by experiment that k is about 140, and for egg shaped shot 3·5 calibres long, $W'/d^3 = 0{\cdot}05$ lb./in.^{3}, while from the subsequent table $\beta - \alpha = 0{\cdot}737$, and this makes O E = $\frac{1}{2} d$, about.

The ellipsoid is the only shape for which α and β have been determined analytically, and this was effected by George Green, in his "Research on the Vibration of a Pendulum in a Fluid Medium, 1833"; the extension to a surface other than the ellipsoid is awaited with interest by the mathematician.

A family of confocal ellipsoids is taken—

$$(23) \qquad \frac{x^2}{a^2 + \lambda} + \frac{y^2}{b^2 + \lambda} + \frac{z^2}{c^2 + \lambda} = 1,$$

and a velocity function

$$(24) \qquad \phi = x\chi,$$

where χ is a function of λ only; and the downward gradient of ϕ in any direction representing the velocity, the normal velocity across the surface of the ellipsoid λ is

$$(25) \quad -\frac{d\phi}{ds} = -\frac{dx}{ds}\chi - x\frac{d\chi}{ds} = -l\chi - x\frac{d\chi}{d\lambda}\frac{d\lambda}{ds},$$

where l, m, n denoting the direction curves of the normal and p the perpendicular from O on the tangent plane

$$(26) \qquad l = \frac{p\,x}{a^2 + \lambda}, m = \frac{p\,y}{b^2 + \lambda}, n = \frac{p\,z}{c^2 + \lambda},$$

$$(27) \quad p^2 = (a^2 + \lambda) l^2 + (b^2 + \lambda) m^2 + (c^2 + \lambda) n^2$$
$$= a^2 l^2 + b^2 m^2 + c^2 n^2 + \lambda;$$

so that in the direction of the normal

$$(28) \qquad \frac{d\lambda}{ds} = 2p\frac{dp}{ds} = 2p,$$

$$(29) \qquad -\frac{d\phi}{ds} = -l\chi - 2p x\frac{d\chi}{d\lambda}$$
$$= -\left[\chi + 2(a^2 + \lambda)\frac{d\chi}{d\lambda}\right] l.$$

In any direction on the surface of the ellipsoid

$$(30) \qquad -\frac{d\phi}{ds_1} = -\frac{dx}{ds_1}\chi,$$

so that the velocity of the liquid may be resolved into a component $-\chi$ parallel to O x, and $-\sqrt{(a^2 + \lambda)}\frac{d\chi}{d\lambda} l$ across the ellipsoid λ.

Any ellipsoid λ may then be considered a thin rigid sheet, swimming along the axis O x, provided the velocity

$$(31) \qquad U = -\chi - 2(a^2 + \lambda)\frac{d\chi}{d\lambda},$$

and so the boundary condition can be satisfied by the form of ϕ in (24).

The continuity is secured if the liquid between the two ellipsoids λ and λ_1 is being squeezed out or sucked in across the plane $x = 0$ at a rate equal to the integral flow of χ across the annular section of the ellipsoids made by $x = 0$: or if

$$(32) \qquad A U - A_1 U_1 = \int_\lambda^{\lambda_1} \chi\frac{d A}{d\lambda}\, d\lambda$$

where $A = \pi\sqrt{(b^2 + \lambda \,.\, c^2 + \lambda)}$.

Expressed as a differential relation, with the value of U from (31),

$$(33) \quad \frac{d}{d}\left[A\chi + 2(a^2 + \lambda) A\frac{d\chi}{d\lambda}\right] - \chi\frac{dA}{d\lambda} = 0,$$

$$(34) \quad 3A\frac{d\chi}{d\lambda} + 2(a^2 + \lambda)\frac{d}{d\lambda}\left(A\frac{d\chi}{d\lambda}\right) = 0,$$

the integral of which is

$$(35) \qquad (a^2 + \lambda)^{\frac{3}{2}} A\frac{d\chi}{d\lambda} = \text{constant};$$

$$\chi = \int_\lambda^{\lambda_1} \frac{M\, d\lambda}{(a^2 + \lambda)\sqrt{(4 \,.\, a^2 + \lambda \,.\, b^2 + \lambda \,.\, c^2 + \lambda)}}$$

where M is a constant, so that χ is an elliptic integral of the second kind.

The quiescent ellipsoidal surface over which the liquid motion is entirely tangential is the one for which

$$(36) \qquad 2(a^2 + \lambda)\frac{d\chi}{d\lambda} + \chi = 0,$$

and this is the infinite boundary ellipsoid, if we take the upper limit $\lambda_1 = \infty$.

The velocity of the ellipsoid defined by $\lambda = 0$ is then

$$(37) \qquad u = -2a^2\frac{d\chi_0}{d\lambda} - \chi_0 = \frac{M}{a\,b\,c} -$$
$$\int_0^\infty \frac{M\, d\lambda}{(a^2 + \lambda)\sqrt{(4 \,.\, a^2 + \lambda \,.\, b^2 + \lambda \,.\, c^2 + \lambda)}}$$
$$= \frac{M}{a\,b\,c}(1 - A_0)$$

in the notation

$$(38) \quad A\lambda = \int_\lambda^\infty \frac{a\,b\,c\,d\lambda}{(a^2 + \lambda)\sqrt{(4 \,.\, a^2 + \lambda \,.\, b^2 + \lambda \,.\, c^2 + \lambda)}}$$
$$= -2abc\frac{d}{da^2}\int_\lambda^\infty \frac{d\lambda}{\sqrt{(4 \,.\, a^2 + \lambda \,.\, b^2 + \lambda \,.\, c^2 + \lambda)}}$$

The impulse required to set up this motion in the liquid of density ρ is the resultant of an impulsive pressure $\rho\phi$ over the surface S of the ellipsoid, and is therefore

$$(39) \qquad \iint \rho\phi\, l\, dS = \rho\chi_0 \iint x\, l\, dS$$
$$= \rho\chi_0 \text{ (volume of ellipsoid)} = \chi_0 W',$$

where W′ is the weight of liquid displaced.

Denoting the effective inertia of the liquid parallel to O x by $\alpha W'$, as in (1), the momentum

$$(40) \quad \alpha W' u = \chi_0 W', \alpha = \frac{\chi_0}{u} = \frac{M}{u}\frac{A_0}{a\,b\,c} = \frac{A_0}{1 - A_0}.$$

Similarly the effective inertia of the liquid parallel to O_y and O_z is

$$(41) \qquad \beta W' = \frac{B_0}{1 - B_0} W', \gamma W' = \frac{C_0}{1 - C_0} W';$$

$$(42) \quad B\lambda, C\lambda = \int_\lambda^\infty \frac{a\,b\,c\,d\lambda}{(a^2 + \lambda, b^2 + \lambda)\sqrt{(4 \,.\, a^2 + \lambda \,.\, b^2 + \lambda \,.\, c^2 + \lambda)}}$$

* No. 1, appeared November 22nd.

$$(43)\ A_\lambda + B_\lambda + C_\lambda = \frac{2\,a\,b\,c}{\sqrt{(4\,.\,a^2 + \lambda\,.\,b^2 + \lambda\,.\,c^2 + \lambda)}}$$

$$A_0 + B_0 + C_0 = 1.$$

The treatment above is submitted to the consideration of the mathematician, as showing the inner meaning of Green's solution, and in a form condensed very much more than usual.

THE NEW UNION STATION AT WASHINGTON.

Those readers of The Engineer who have been to Washington will no doubt agree that it is the most beautiful of all the cities of America, but they will probably also agree that whilst there are well-arranged wide streets, fine buildings, and ample open spaces, the station accommodation is meagre and wretched. The Pennsylvania terminus is small and unsuitable, and is approached by rail over a series of dangerous road crossings, whilst anyone who has seen the old timber shed that does duty as a station for the Baltimore and Ohio line will not readily forget it.

For years proposals have been under consideration for putting the station accommodation, and the approaches thereto, on a modern footing, which included the abolition of the grade crossings, but such proposals did not meet with the approval of the national and local authorities. In 1901 schemes were approved and the sanction of Congress obtained—this being necessary owing to the property being in the district of Columbia, and therefore under Federal control—for a new passenger and freight terminus for its Baltimore and Ohio near its present station, and for the enlargement of the existing Pennsylvania station, the abolition of the level crossings, and improvement of alignment.

This was regarded as a settlement of the railway situation, and steps were taken to put the necessary works in hand, property being purchased with that end. But the whole matter was soon again in doubt, and that on a side issue. Eight days after the signing of the Acts sanctioning the railway improvements a resolution was passed in the Senate whereby a Commission was appointed to consider and report on the development and improvement of the parks in the district of Columbia. It soon became evident to this Commission that the park system could not be amended so long as the Pennsylvania tracks remained in their present position, whilst, were they removed, the greatest possible improvement could be made. It was further considered unfortunate that the Baltimore and Ohio new terminus should be within a square of the Capitol grounds.

This led to the suggestion of a joint or union station into which both the companies could run, but owing to the position of the existing lines, and to the distance between them, it was not possible to achieve this without raising a protest from the public.

If the map in Fig. 1 be studied, the railway situation in Washington will be understood. The Philadelphia, Baltimore, and Washington Railway—the Pennsylvania—comes from the south-east, crosses the Anacostia River by a trestle bridge, and proceeds, as shown, through the streets and practically level therewith to the junction between Virginia (Pa.) Avenue and Sixth-street, when it turns to the north and enters the present terminus, which is off Pennsylvania-avenue. There is a connection south of the terminus—at Maryland-avenue—to the south and over the Potomac by the Long Bridge, and it is by this connection that the Southern Railway enters Washington.

Also from the south-east is a branch of the Baltimore and Ohio line to Alexandria, whereby it exchanges traffic with the Southern, but this has no connection with this subject.

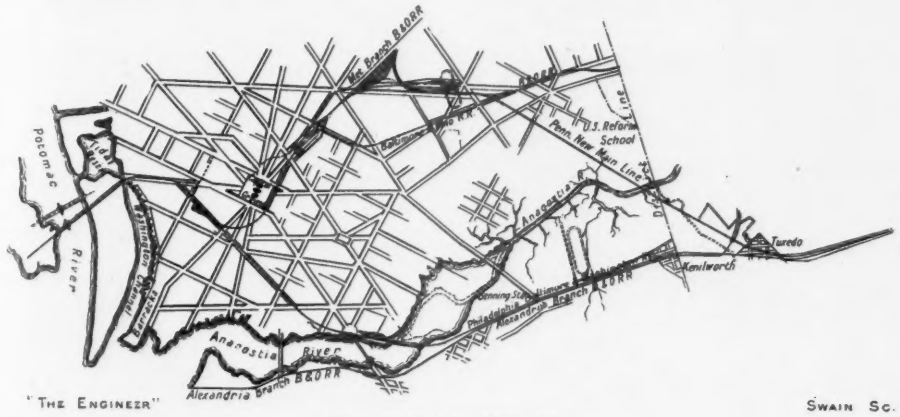


Fig. 1—PLAN OF WASHINGTON

The Baltimore and Ohio station is north of the Capitol at the intersection of New Jersey (N.J.) Avenue and C-street. It has two lines, the Metropolitan which enters the Congressional Library, there was considerable prejudice raised against a proposal to construct and operate a tunnel so near such important national buildings. It was, however, realised by all concerned that this was the correct course to take, and so in 1903 an Act was passed sanctioning the scheme shown in Fig. 1, which will cost about £4,000,000, and that covers a total area of 160 acres.

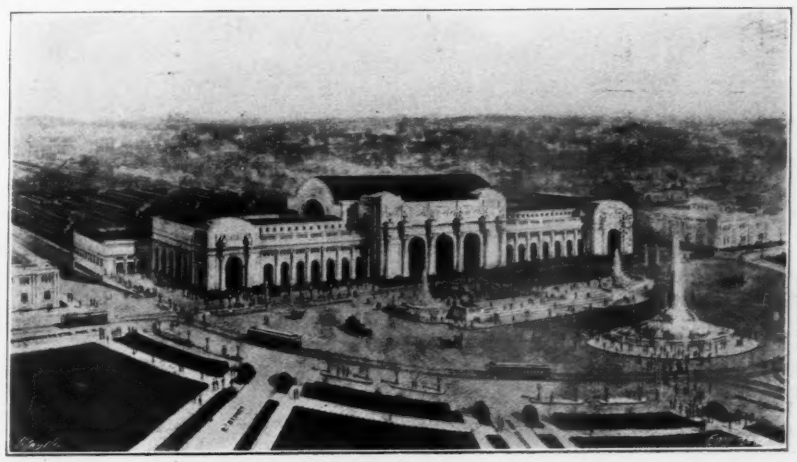


Fig. 2—GENERAL VIEW OF THE UNION STATION

along First-street-east, and the main line which comes from the north-east and along I-street.

The readiest route for the Pennsylvania to join the Baltimore and Ohio would be by a tunnel under First-street-east, but as this would be between the Capitol and

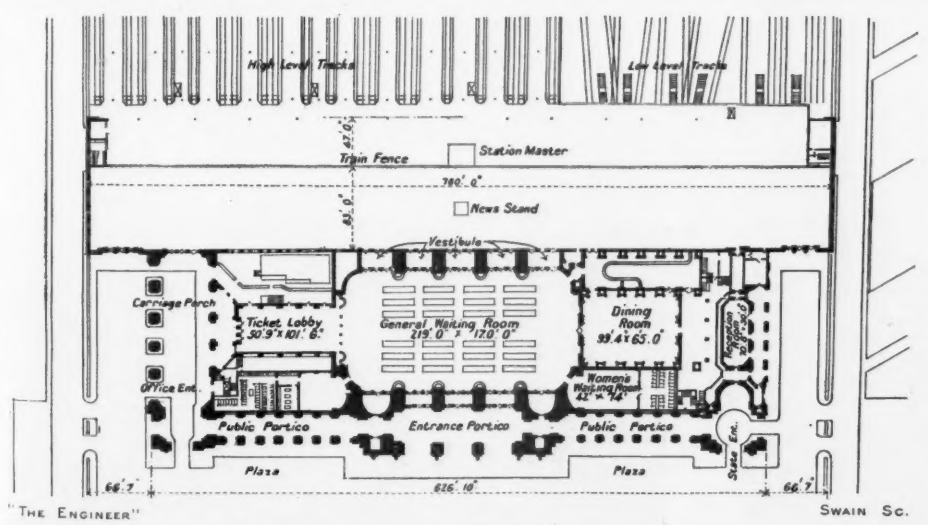


Fig. 3—PLAN OF FIRST FLOOR OF STATION BUILDINGS

Fig. 1, which shows the trestle bridge, 35ft. high, used for conveying the filling-in. In the foreground is the contractor's yard, and on the extreme left can be seen a small portion of the concrete construction for the front of the entrance buildings. Fig. 8 looks eastward.

Fig. 2, which is from a picture, the copyright of which is the property of the Pennsylvania Engraving Company, of Philadelphia, gives an idea of what the station structure and its public approaches look like. It was considered fitting that this, the only gateway of the Capitol, should be in keeping with the other public buildings of the city, which have drawn their architectural inspiration from Greece and Rome, and therefore the designs were based on the triumphal arches of Rome.

The three central arches, 80ft. wide and 50ft. high, greatly exceed in size their Roman prototypes. The concourse is 130ft. wide and 760ft. long, and covers an area of 2¼ acres. The platform superstructure is 620ft. long and 220ft. wide, and covers an area of 3¼ acres. The public carriage entrance is through the 40ft. arch on the west or left-hand side. The 40ft. arch on the east leads to the State entrance, where there are rooms reserved for the President and guests of the nation.

The main floor level is about 35ft. above the former ground level, and about one million cubic yards of filling-in have been necessary to make the approaches suitable. Fig. 7 will give an idea of what has been required. This looks southwards, and the road crossing the picture is Massachusetts-avenue, that at right angles to it and leading towards the Capitol—seen behind the derrick—is Delaware-avenue. The square tower on the right is at the Baltimore and Ohio Station. The wall on the left is part of the tunnel under First-street. The construction of the approaches has been assisted by the formation of the plaza, as shown in Fig. 2. This will be 940ft. long, and will be decorated with fountains, balustrades, and terraces. From the plaza will lead nine separate streets or avenues. These will give ample conveniences for the public to get to and from the station, whilst the space afforded by the plaza will serve for massing troops and spectators on ceremonial occasions.

The filling-in for the plaza and approaches was obtained from a hill that was removed to make room for carriage, &c., sidings, and Fig. 8 shows the trestle bridge,

Fig. 5 shows more clearly the construction of the front of the station as looking northwards. Fig. 6 gives a view of the front as seen from near the north east corner of the entrance buildings, and which shows the extent of the supports for the west half of the main building. The foundations are, as a rule, 45ft. in height.

Fig. 3 is a plan of the first floor of the station buildings. Intending passengers who enter by the central arches pass into the general waiting-room, which is 220ft. long, 130ft. wide, and covered by a Roman barrel vault 90ft. high. This room is decorated with sunken panels after the manner of the baths of Diocletian. Fig. 9 shows the general waiting-room under construction. The semi-circular windows at each end—Fig. 9 shows the west end—are 75ft. in diameter, and the five windows at the side are 30ft. in diameter. Passengers from the front portico enter through the openings on the left. On the left of the entrances are the telephone booths, and on the right a drug store.

On the west of the general waiting-room is the ticket lobby, on either side of the entrance to which are the offices of the two telegraph companies. Fig. 10 shows the ticket lobby under construction. The entrance in the background is that used by passengers who arrive by the carriage entrance. The booking offices are on the left, and on the right are the baggage rooms. Behind the booking office is the accommodation for men—smoking-room, barber's shop, and toilet-rooms. The entrance to the men's rooms is seen in the corner of Fig. 9, on the left of the scaffolding.

On the opposite, or east side of the general waiting-room, is, on the right, the women's rooms. In the centre is a magnificent dining-room, 65ft. long and 44ft. wide. On the left is a lunch-room. Behind the dining-room is the serving-room.

On the extreme right is the State entrance, already referred to, an outside view of which is given in Fig. 11. Immediately inside is a vestibule, whence there is a passage to the right leading to the President's retiring room. On the left is the attendant's room. In the

NEW UNION STATION AT WASHINGTON

(For description see page 539)

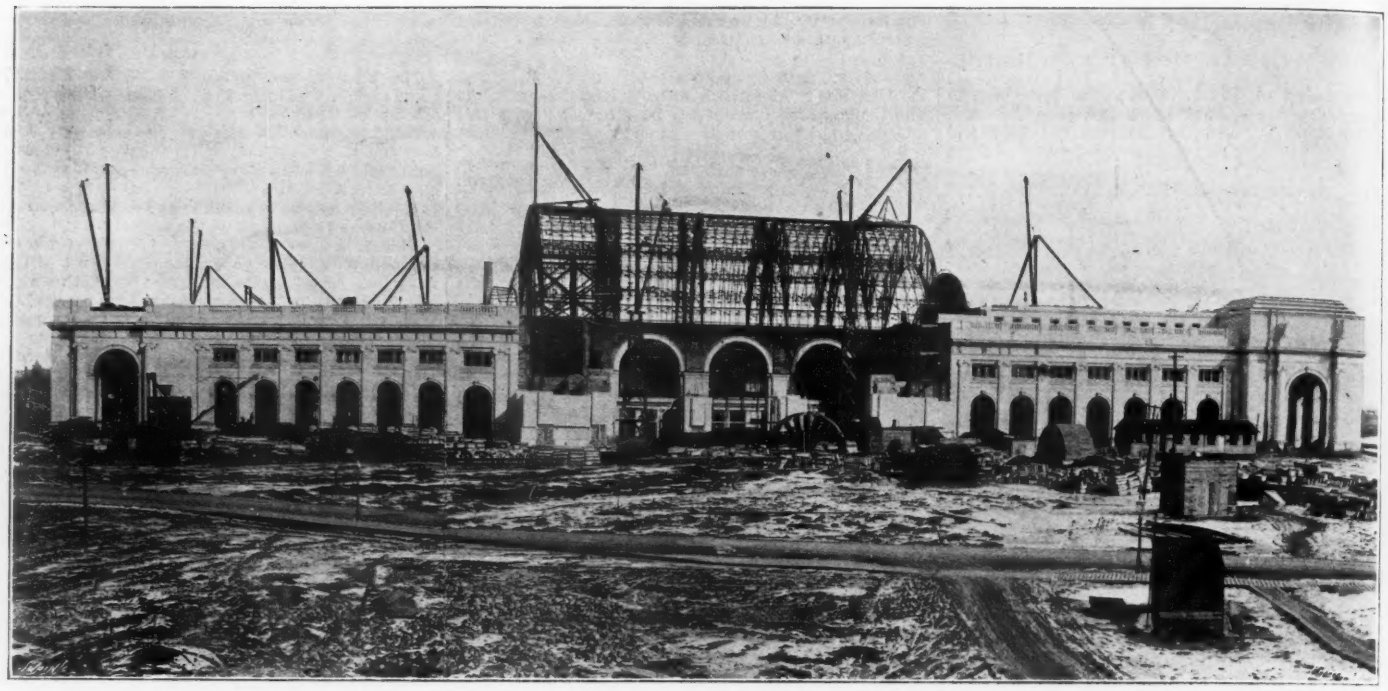


Fig. 4—FRONT VIEW OF STATION—MARCH 1st, 1907

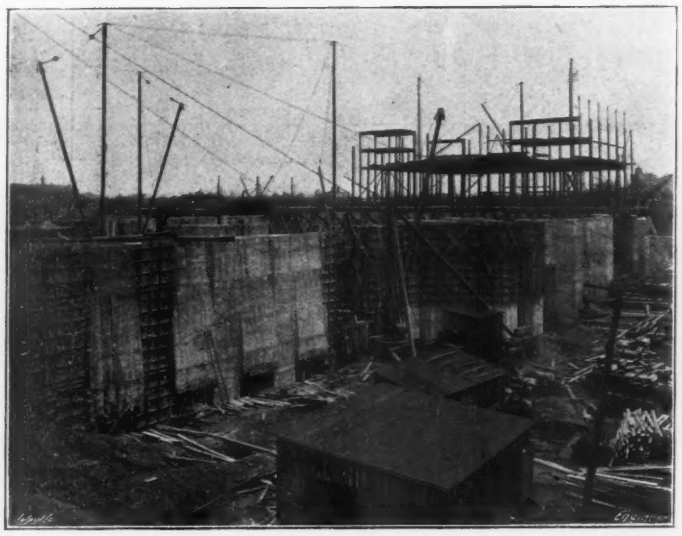


Fig. 5—FRONT WALL OF STATION

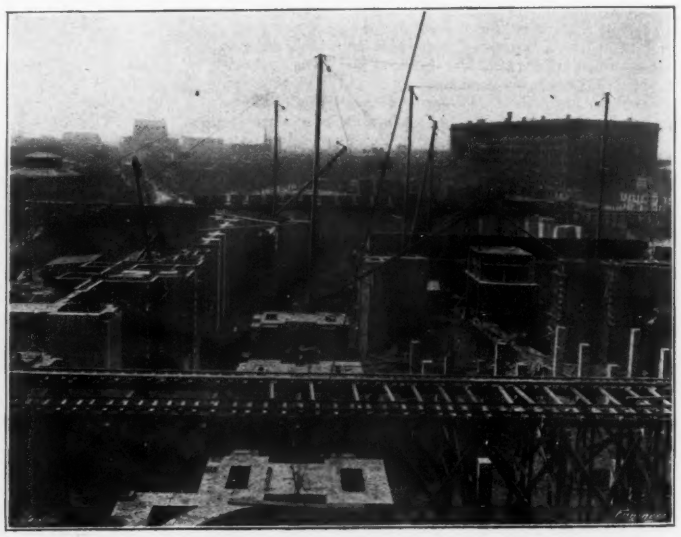


Fig. 6—CONSTRUCTING FOUNDATIONS

Fig. 7—DELAWARE AND MASSACHUSETTS AVENUES BEFORE FILLING IN

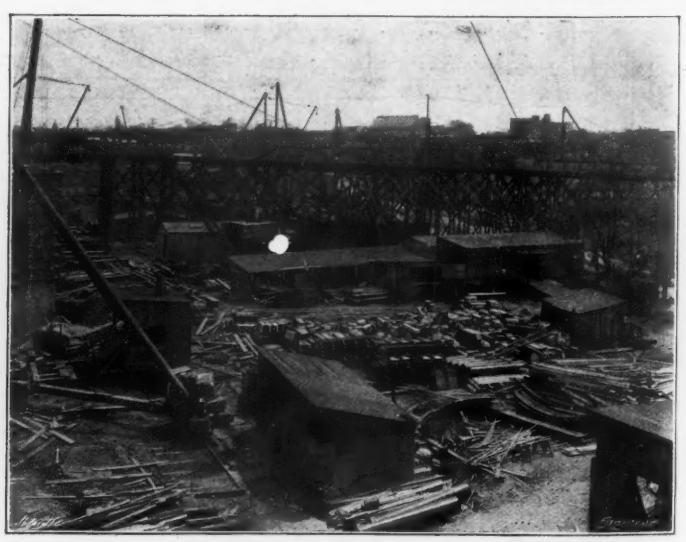


Fig. 8—SPACE IN FRONT OF STATION

centre is the reception-room, 70ft. long and 30ft. wide, with three doors leading on to the portico seen in Fig. 11, and with doors at the far end giving access to a vestibule that leads on to the station platforms. Between the serving-room of the dining-room and the reception-room is a passage-way that allows communication between the State apartments without going through the reception-room. In the north-east corner of the State apartments is a room that was intended for the use of invalids arriving at, or departing from, the station. It is, however, to be used as a women's room. The four recesses be seen the gateways leading to the basement on the east side. There is a similar entrance on the west side. All the heavy baggage is dealt with in the basement.

Leaving the main building, let consideration be given to the approaches. After crossing the new steel bridge across the Potomac, and passing the Southern Railway Yard, the line will be in walled cut, with the streets carried over, as far as the intersections of Maryland and Virginia-avenues, whence they will pass to an elevated structure, with the streets carried under the tracks. The elevated structure will be of sufficient width to carry four felt laid in waterproofing compound. Upon this is laid 1in. of cement mortar for the open work and a layer of brick for the drift portion.

Of the 4010ft. the southern 950ft. are open cut, the next 2480ft. drift work and the northern 600ft. open cut. As no shafts were allowed the drift tunnel was constructed from the south end. The plant for mixing concrete and handling material was erected at the southern end, and was operated, as well as the motive power for conveying the concrete to the works, by electricity. The shovel for removing the material was operated by compressed air.

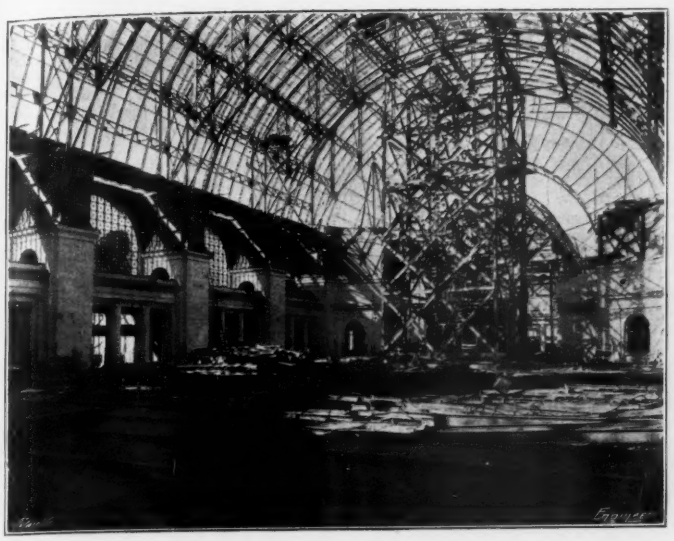


Fig. 9—INTERIOR OF WAITING-ROOM

Fig. 10—TICKET LOBBY

Fig. 11—STATE ENTRANCE

Fig. 12—THE CONCOURSE

between the lunch-room and the station platform are to be used as a news stand, ticket and telephone offices, and an information bureau. On the second and third floors of the station buildings there will be offices. Stairways to these are on the left of the State entrance, and from the carriage portico.

Fig. 4 shows the outward appearance of the entrance as it was on March 1st last. This, when compared with Fig. 5, shows what filling-in has been done.

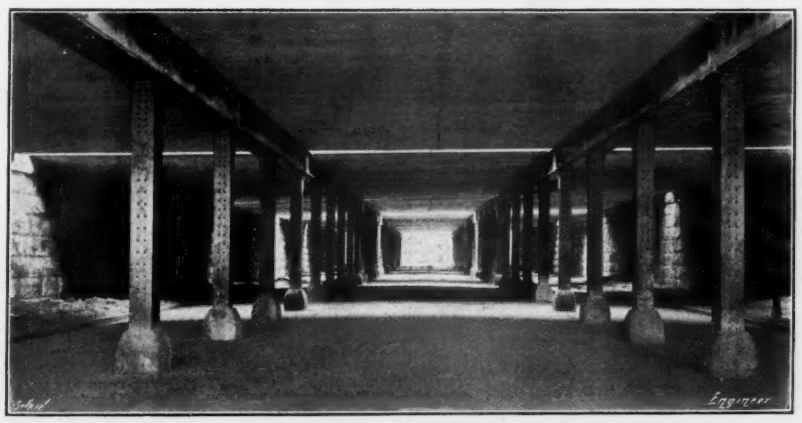


Fig. 13—UNDERBRIDGE AT K-STREET

Fig. 12 is a view, from the east, of the concourse, which is 760ft. long—9ft. longer than the Capitol itself—and 130ft. wide. A fence, through which passengers will pass by gates to and from the trains, will be fixed 83ft. from the inner wall. It is intended that arriving passengers shall leave by the approaches to the left of the carriage entrance on the left, and on the right of the State entrance. Outside these approaches are roadways that give access to the basement. These roads fall from the front entrance on a 6 per cent. gradient, and in Fig. 12 will

lines of way. From Garfield Park to the point near Ninth-street-east, where the present route is struck, the line will be in tunnel. From Second-street-west this portion, after the new terminus is opened, will be used entirely for freight traffic. It is at Second-street-west where the new line to the terminus comes in, and which, up to New York-avenue, is on viaduct. At this point the new tunnel under First-street commences. This is 4535ft. long, of which the southern 4010ft. are in twin tunnels built side by side. The division wall between the tunnels is of stone, and is 4ft. thick, and contains openings at intervals of 100ft. to provide access between the tunnels and as refuges for the trackmen. Each tunnel is 16ft. wide and 17ft. high from the top of rail to the soffit of the arch. The side walls and haunches are constructed of concrete and the arches of four rings of brick. The conduits for the electric wires were laid in the haunching as it was constructed. The top and a portion of the sides are protected by four layers of waterproofing By these means all smoke and gas were avoided, and the workmen were able to perform their duties under the most favourable conditions without adding materially to the cost of construction.

The crown-bar system of timbering was first employed in the removal of the earth from the space in which the arch was to be built. Segmental timbers were then placed inside the crown bars to strengthen the work. The tunnel has, therefore, outside of the masonry, timber aggregating 2ft. in thickness to support the overlying material. The work on one tunnel, embracing a foot way and the middle wall with connecting arch, was carried on somewhat in advance of the other.

The northern 525ft. of the tunnel are constructed of girder-covered way, and the width ranges from 115ft. at the north end to 36ft. at the point where the twin tunnels commence.

Turning now to a consideration of the train accommodation. The station is on two levels. The high level is 480ft. wide, is on the same level as the concourse, and has twenty tracks. The low level is 280ft. wide, has thirteen tracks, and is reached by steps from the concourse, as seen in Fig. 3. This lower level is necessary for the accommodation of trains to and from the south, which pass through First-street tunnel, and the difference between the two parts of the station is clear from Fig. 12, the low level being in the foreground, and the retaining wall supporting the main level is in the background. At the edge of the concourse the low-level lines are 20ft. below the main level.

Roads No. 4, 5, 10, 11, 16, and 17 are set aside exclusively for the handling of baggage. Lifts are provided between each pair of these roads for passing the baggage to and from the baggage rooms, which, as has already been said, are in the basement. As some trains carry more baggage than others, such trains will, as far as possible, be dealt with on the roads adjacent to the baggage tracks.

The high-level tracks fall and the low-level tracks rise from the concourse to a point near I-street, where they coincide.

The platforms are 30ft. wide, and will be about 900ft. in length. They will have umbrella roofs.

The west retaining wall has been constructed in such a manner as to contain a tunnel 12ft. wide and 13ft. high, in which will be carried the heat, air, water, and hydraulic pipes, and the electric light and power wires. This was

carried under H-street, and a branch tunnel 5ft. wide and 7ft. high was constructed along the north abutment of that street to carry the necessary pipes and wires to the Express Company's building on the opposite side of the railway.

H-street is immediately north of the ends of the platforms, and there are also under-bridges at K, L, M streets and Florida-avenue. These vary in length from 790ft. at H-street to 135ft. at Florida-avenue, and they are each 80ft. wide, divided into spans of 27ft. 6in., 25ft., and 27ft. 6in. Fig. 13 gives a view of that at K-street. This is 450ft. long. These bridges are constructed essentially of I-beams, encased in concrete. Upon the top is placed a layer of waterproofing material, protected by a layer of reinforced concrete, 5in. thick. At intervals between the tracks are placed vault lights.

In addition to the thirty-three tracks in the station there will be five sidings. The Express Company's building is on the east side, its southern end being near H-street. For its accommodation there are four platforms and ten sidings. Near there is the east coach yard with four sidings, and on the opposite side of the line, north of the power-house, is the west coach yard with four sidings, also an 80ft. engine turntable with sidings for locomotive purposes.

All the roads converge into ten running lines near L-street. These lines are devoted as follows, reading from the east:—Shunting track, two Pennsylvania lines, two Baltimore and Ohio main lines, two "equipment" tracks for engines and cars to and from the sheds, two Baltimore and Ohio metropolitan branch lines, and a freight track. At Florida-avenue the Pennsylvania and Baltimore and Ohio main lines turn to the right, and between those lines and the metropolitan branch has been laid out a large coach yard, covering 60 acres and accommodating 750 cars. Into this yard run the "equipment" tracks above referred to, which then continue alongside the Baltimore and Ohio main lines to the engine round-house, shops, and storage yard. Two half-circle engine-houses are to be provided, each holding twenty-five engines, having two 80ft. turntables between and being accessible from both sides. They are equipped with the latest ideas for handling and weighing coal and for the disposition of ashes. The engine yard, &c., covers 55 acres, and from the space covered by the coach and engine yards 2½ million cubic yards of material have been removed.

The signalling of the terminal and yards is on the electro-pneumatic principle, and will be carried out by the Union Switch and Signal Company. There will be three large signal-boxes—one for the whole of the station, one at the junction near New York-avenue, and one near the engine shed. In addition, there will be a small box near the northern end of First-street tunnel, for operating the switches where the lines converge into two at the entrance to the twin tunnels.

As was said in the introduction, the work is joint between the Pennsylvania and Baltimore and Ohio companies. The dividing line for construction purposes has been the northern end of First-street tunnel. The terminal and all north thereof has been carried out by the Baltimore and Ohio, whose resident engineer is Mr. W. F. Strouse, to whom we are indebted for the material for this article. The First-street tunnel and the Virginia-avenue improvements, &c., have been carried out by the Pennsylvania, whose resident engineer is Mr. Robert Farnham. The architects for the terminal buildings are P. H. Burnham and Co., of Chicago.

THE FUTURE WATER SUPPLY OF LONDON.

No. I.

In a leading article we discuss a report recently made by the Works and Stores Committee of the Metropolitan Water Board to that body regarding the future water supply of the metropolis. In the following articles we propose to enter more fully into the details of the proposals which have been put forward both in this report and in other reports which have been from time to time laid before the Board by their chief engineer, Mr. William B. Bryan, M. Inst. C.E., and we would acknowledge our indebtedness to Mr. E. B. Barnard, M.P., chairman of the Works Committee, and to Mr. Bryan and his staff for the courtesy with which they have afforded to us opportunities for obtaining particulars and information regarding this important question.

The subject of the water supply to an enormous population such as that gathered within the area covered by the operations of the Board is a matter of great difficulty and complexity. As our readers are aware, it has been inquired into by many Royal Commissions, the last three of which were the Duke of Richmond's in 1869, Lord Balfour of Burleigh's in 1893, and Lord Llandaff's in 1900. We shall have frequent occasion to refer to the findings of the two last Commissions in what follows.

In order to obtain a thorough grasp of the requirements of the future it is helpful to glance at what has happened in the immediate past. To do this the figures of population and amount of supply should first be studied. From a table given in a report made by Mr. Bryan in December last we find that in 1881 the average daily supply was nearly 144 millions of gallons, and the population dealt with about 4⅓ millions. During the year 1906-7 the average daily supply had grown to over 225 millions, and the population to over 6,850,000. The whole question of how much water will be required in the near and remote future depends, of course, on how the population will vary. It is, unfortunately, impossible to predict with certainty to what extent the population in the water area will grow. Very careful estimates have been made, and tables and calculations were given in the report of the Balfour Commission. These are, of course, too lengthy to be reprinted here, but in the main they have been accepted by Mr. Bryan, and in the report just made to the Board by its Works and Stores Committee there is the following table:—

Date.	Estimated population.	Estimated average daily supply. Million gallons.
1916	8,031,000	281
1921	8,703,000	305
1926	9,431,000	330
1931	10,221,000	358
1936	11,076,000	388
1941	12,000,000	420
1948	13,428,000	470
1954	14,857,000	520
1960	16,286,000	570

The estimated average daily supply is obtained by calculating on a consumption of 35 gallons per head in twenty-four hours. We have dealt with this figure at sufficient length in our leading article, and there will not be any further need to refer to it here. In any case, it would not, we think, be safe for a less figure to be counted in.

The problem to be faced, therefore, is the supply of a gradually increasing amount, which will finally grow to 570 million gallons a day in 1960, and thereafter a yearly increasing quantity. It will be observed that in fifty years from now the additional demand for water will, it is estimated, be 570 − 225 = 345 million gallons a day—rather more than 1½ times as much as it is at present That an increased quantity would be required in the future has, of course, been acknowledged for a long while, and numbers of suggestions for obtaining further supplies have been brought forward from time to time. Those laid before the three Commissions above referred to are the following:—(1) Mr. J. F. Bateman, the engineer of the Glasgow, Manchester, and Thirlmere Waterworks, proposed to derive a supply from a catchment area of about 204 square miles on the tributaries of the upper parts of the Severn. The water would have to be brought by a conduit 183 miles long, terminating near Stanmore, where it was proposed to construct a service reservoir of 2000 million capacity. In this case the contemplated gross reservoir capacity was to be 41,932 million gallons in seven reservoirs; the average daily supply, 230 million gallons; and the estimated cost £11,400,023. (2) Mr. Hamilton H. Fulton proposed to appropriate a gathering ground in the Upper Wye above Hay, Builth and Rhyader. In this case the water would have to be brought 180 miles to a point near Barnet; the gross reservoir capacity was to be 26,000 million gallons, in six reservoirs; the average daily supply 230 million gallons, and the estimated cost £9,000,000. (3) Messrs. Hemens and Hassard's proposal was to utilise the waters of Thirlmere, Ullswater, and Haweswater. The water was to be brought to London by a conduit 270 miles in length; there were to be service reservoirs near Edgware with a capacity of 3750 million gallons; the gross reservoir capacity was to be 34,657 million gallons; the average daily supply 287 million gallons; and the estimated cost £13,500,000. (4) Mr. George Remington suggested the appropriation of an area of 262 square miles in the Derbyshire hills, and the bringing of water from the river Dove to a reservoir on Barnet Hill—a distance of 135 miles. The contemplated gross storage was 6000 million gallons; the average daily supply 100 million gallons; and the estimated cost £5,000,000. (5) Messrs. McClean, Stileman and Blackwell proposed to canalise the Thames near Henley, making a series of impounding reservoirs, and to bring the water to London by a conduit 36 miles long. The average daily supply was to be 200 million gallons, and the estimated cost £1,500,000. (6) Mr. Bailey Denton suggested the purchase of the Thames and Severn Canal and the North Wiltshire Canal, and to utilise them for the collection of supplies from the Thames, and to bring the water from Lechlade to London by a conduit 127 miles long, taking in other supplies on the way. This and other suggestions brought the total daily supply up to 200 million gallons. The estimated cost was £5,320,000. (7) Messrs. T. Crowther Brown and J. Bravender suggested the supply of pure water for drinking purposes only from wells in the upper Thames district. (8) Mr. R. W. Mylne proposed to collect water from the upper tributaries of the Lea into reservoirs, &c. The proposed gross storage was 3140 million gallons, the average daily supply 70 million gallons, and the estimated cost £1,250,000. (9) Mr. T. Hennel suggested the purchase of the Basingstoke Canal and the utilisation of it as a conduit for bringing water from adjacent sources. His contemplated gross reservoir capacity was 840 million gallons, the average daily supply 14 million gallons, and the estimated cost £280,000. (10) Mr. J. Whiffen-Ewens wanted to bring 50 million gallons a day from the Sussex chalk springs near Emsworth, the water to be pumped into reservoirs in the Portsdown hills, near Petersfield. The estimated cost of this scheme was £1,280,000. (11) Mr. Telford McNeil proposed to pump water from the Thames at Teddington and to lead it through the Basingstoke Canal to the Bagshot sands for filtration, and to carry it back to storage reservoirs at Norwood and Hampstead. The daily average supply was to be 200 million gallons, and the estimated cost £6,000,000.

The foregoing were all of them brought before the Richmond Commission. It will have been observed that several of the proposals are now out of date by reason of the sources having been otherwise appropriated. Some of the ideas may be almost designated as grotesque, while others were manifestly inadequate.

The following four proposals were submitted to the Balfour Commission:—(1) Professor Henry Robinson, on behalf of the London water companies, suggested the construction of three reservoirs in the Kennet Valley to contain 46,652 million gallons, the function of these reservoirs being to maintain a minimum flow of 600 million gallons at Teddington. The scheme contemplated an average daily supply of 300 million gallons, and the cost was to be £3,000,000. (2) Messrs. H. J. Marten and Rofe, on behalf of the Thames Conservators, proposed the formation of storage reservoirs upon various tributaries in the Upper Thames Valley at a cost of £1,962,225. The daily supply was to be 136 million gallons. (3 Mr. More, the engineer of the Thames Conservancy, suggested the formation of compensation reservoirs in the old deer park at Richmond. The object of these was to impound 50 million gallons of each rising tide; that is to say, 100 million gallons a day during flood, to be let out again at the tail of the ebb. This, it was thought, would enable 200 million gallons a day to be withdrawn without any harm being done to the river in any part of its course. (4) Messrs. Walter Hunter and A. Fraser suggested the construction of nine reservoirs at Staines, and a daily supply of 300 million gallons at a cost of £5,391,435. This scheme, it will be remembered, was only carried out in part.

Only one proposal was brought before the Llandaff Commission, and it was that elaborated by Sir Alexander Binnie on behalf of the London County Council. Most of our readers will remember its general outlines. Sir Alexander's scheme included the construction of a storage reservoir by building a dam across the river Yrfon, a tributary of the Wye, the formation of a lake with a gross capacity of 39,000 million gallons and an available capacity of 35,700 million gallons. It was also proposed to divert the Towy by a tunnel 4½ miles long into the Yrfon reservoir, thus obtaining an extra 44 million gallons a day. An aqueduct 117 miles long and a pipe line 45 miles long were to be capable of carrying 200 million gallons a day to London. The terminal works were to be at Elstree. The suggestion was to carry out the work in two instalments, the first of which was to provide 147 million gallons a day at a cost of £14,112,000, or, as an alternative, 114½ million gallons a day at a cost of £10,032,250, while the second was to increase the 147 million gallons to 200 million gallons a day at a cost of £2,434,000.

Only one of these schemes was acted on in any way, and that—the Staines proposal—as has been said, in a modified form. Not one of them indicated an additional supply of more than 300 million gallons a day. Hence everyone of them must be considered as not fully meeting the requirements even up to the year 1960. Indeed, supposing any one of the schemes proposing 300 million gallons a day in addition to the present 225 million gallons had been adopted, this would only represent a total of 525 million gallons a day, and would not, as will be seen from the above table, take us very much further than the year 1954.

The foregoing by no means represent the whole of the schemes which have been brought forward, but we need only mention one other which was drawn up by Messrs. Richard, Hassard, and Arthur W. N. Tyrrell, M.M. Inst. C.E., and brought before the London County Council in 1891. The sources of supply proposed were the districts drained by the rivers Usk, Yrfon, Elan, Claerwen, and the upper Wye. It was estimated that a daily supply of some 300 million gallons would be obtained. It was suggested that lake Langorse and other lakes should be dammed and enlarged, and that there should be an aqueduct 162½ miles long to the north of London. The cost was estimated at £15,500,000. This scheme was subsequently revised, and proposals made to increase the daily supply to 430 million gallons daily by leading into the aqueduct the discharges of springs near Cirencester; between Bourne End and Reading; on the Southdown Hills eastward and Havant; on Hindhead; and in Wolmer Forest. With regard to this scheme, which was no doubt the foundation of that of Sir Alexander Binnie, it must be borne in mind that the water obtainable from the rivers Elan and Claerwen, amounting to 30 million gallons a day, have already been appropriated for Birmingham.

Of all the foregoing, that of Messrs. Hunter and Fraser alone suggested the formation of large areas of storage reservoirs in the Thames Valley, so that considerable bodies of water might be taken from the Thames during flood, at a point reasonably near London, so as to permit of a large daily supply. The scheme, however, did not meet with full approval, and, as already remarked, it was only carried out in part, or perhaps it is more correct to say that only a relatively much smaller undertaking, which, however, evidently had its origin in the original proposal, was sanctioned. Nevertheless it is in the direction of gradually increased storage in the valleys of the Thames and its tributaries, until the total daily supply from the river amounts to some 450 million gallons, that the Board proposes to proceed. How it is intended to do this, and why it is not proposed to go any further than 450 million gallons, we shall show in our next article.

Landing Passengers at Cuxhaven.—A very great improvement in the method of landing passengers has been effected at Cuxhaven by the Hamburg-American Company, by the employment of an adjustable gangway. As most people know, the ordinary gangway generally employed on piers, landing-stages, &c., is often pitched at very inconvenient angles, making the landing and embarking of passengers, luggage, &c., somewhat difficult, especially if the sea be rough. With the apparatus at Cuxhaven, which was designed and patented by Captain John Iron, the Harbour Master of Dover—described in The Engineer, June 17th, 1904—this is avoided, as the gangway can be adjusted to suit the height of the vessel's deck at all states of the tide; moreover it is firm and steady in all weathers, rapidly placed in position, and the landing and embarking of passengers, luggage, also horses and cattle carried out much more quickly and without risk. The gangway was constructed by Messrs. Merryweather and Sons of London, to drawings provided by Captain Iron, and consists of a movable tower running on wheels—so that it can be easily put alongside a vessel at a pier—with a rising and falling platform to which the ordinary gangway or bridge to afford access to the ship is connected, giving a practically level footway. At the side of the tower is a hinged gangway of suitable length to, give an easy descent from the tower platform. Captain Iron has, as our readers will remember, had one of these adjustable gangways in use at Dover some time now, and it was after seeing this one in use that the Hamburg-American Company decided to adopt the same system at Cuxhaven, the company being very much impressed by the convenience and satisfactory working of the apparatus.

RAILWAY MATTERS.

THE new London County Council electric tramway line from Goose Green, East Dulwich, to Newlands, close to Brockley, was recently opened to the public.

THE takings last week on the South Shields Corporation tramways amounted to £490 5s. 11d., the number of passengers carried being 121,787, and the average per car mile 8·34.

AS the express from Barcelona was crossing a river between the stations of Hospitalet and Cambrils, in Valencia, it left the rails, and fell from the bridge into the river. There was a considerable number of passengers travelling by the train.

OPERATIONS have commenced on the new branch line of the Great Western Railway line at Cwmrhydyceirw and Lonlas, Llansamlet. It is expected that tunnelling will be begun under the Peniel Green and Lonlas land at Llansamlet at the opening of the year.

WE hear that the Pennsylvania Railroad has cancelled the great order for locomotives which it recently gave to Baldwin's works, with the result that the latter company has had to discharge 8000 workmen, and there is a prospect of the dismissal of another 9000.

PLANS are now being matured for the electrification of some of the suburban railways of Melbourne, Australia. These lines, which belong to the State, have a large passenger business, and the project of adopting electric traction has been under consideration for a long time.

A THROUGH service from Leven to Kirkcaldy was commenced by the tramway company in agreement with Kirkcaldy Corporation on the 13th. Cars are run every twenty minutes from Monday to Fridays, and every ten minutes on Saturdays. An accelerated service is promised on Sundays.

THE electric tramway service between Bexhill and Hastings has been greatly improved by the running of through cars, which obviates the changing by passengers at West Marina. Cars have now been fitted so as to work on the trolley system which exists in Bexhill and on the surface contact system on Hastings front.

THE Chicago, Rock Island, and Pacific is now among the roads which publish "merits" credited to employés for doing more than their duty. Some of the credits appear to have been made with a liberal hand, as, for example, one to a man who was very prompt in responding to a call for the wrecking car. A passenger brakesman in Oklahoma received 10 merits because, while his train was delayed a long time by a washout, he borrowed a broom and swept and dusted the coaches.

RECENT railway legislation in Massachusetts requires every steam railroad in the State to instal, subject to the approval of the Board of Railroad Commissioners, a spark arrester on every locomotive in which wood, coal, or coke is burned. The commissioners are making determined efforts to protect woodlands near the railroads from fire. Efforts in spark arresting are almost as old as locomotives, but there is still room for ingenuity in this direction, and the subject is worthy the attention of inventors.

MORECAMBE Town Council, at a special meeting last Monday evening, unanimously decided to promote a Bill in Parliament authorising them to purchase, construct, and work tramways. At present the system of tramways along the sea front is by horse traction, and is run by a private company, whose lease has expired. The Corporation are now seeking to acquire the undertaking in the Morecambe district, with a view to electrification. While the Council are unanimous in the acquisition of the tramways there are divided opinions as to electrifying them

IN connection with the refusal of the Board of Trade to sanction the new tramway between Willesden Green and the Harlesden point of the Harrow-road, costing £20,000, on the ground that it is "interlaced," which means that two tramway cars cannot pass each other, fresh action has been taken. Notice was recently given in the *London Gazette* of the intention of the Metropolitan Electric Tramways to ask Parliament for power to acquire certain lands on each side of the High-road, Willesden, presumably for the purpose of widening the road and laying down double lines.

THE French are slowly pushing their railway from Tonkin into the province of Yünnan. At the end of 1906 it was open in Chinese territory from Ho-k'ou for a distance of 19 miles; in May of the present year the distance was increased to 44 kiloms., or 27 miles, and as work is being rapidly pushed forward along the whole line, it is anticipated that it will be open as far as Mengtzu in April, 1908, and that in from eighteen months to two years thereafter—that is to say, at the close of 1909 or beginning of 1910, the whole of the 292 miles to Yünnan Fu will be built and in working order.

NEXT Saturday the Strand Station of the Great Northern, Piccadilly and Brompton Railway is to be opened for traffic. This station, which is the last to be completed on the Piccadilly Tube, will bring the whole of North and West London into direct communication with the East Strand district. The station is built on the site of the old Strand Theatre, and is within a minute's walk of the Law Courts, Fleet-street, Somerset House, and the Gaiety, Aldwych, and Waldorf Theatres. The fares to be charged from the new station are practically the same as those already in operation from Holborn Station.

THE directors of the Central London Railway had under consideration, at a recent meeting, the question of introducing penny fares. The competing omnibus companies have threatened that if the change is made they will lengthen their penny stages along the tube route. On the other hand, they have offered to shorten the present penny stages if the Central London will adhere to its minimum of 2d. After over an hour's discussion the directors decided, it is understood, that if the omnibus companies will agree to proposals which will be submitted to them at an early date, with regard to their penny stages, the Central London will adhere to its present tariff.

THE North-Eastern Railway Company, it is reported, has decided on an important scheme for extending its coal-shipping facilities at Tyne Dock, and for this purpose will promote a Bill in the next session of Parliament. It proposes to divert the river Don from its present course along the Jarrow Slake edge of the dock to a new and more direct channel 170 yards to the westward, to dredge the large portion of the Slake between the western limits of the existing dock and the new channel, and to erect thereon large coal staithes of the most modern type. This proposal has been brought about owing to the congested state of the dock and the pressure from shipowners and others.

A COLLISION occurred last Monday in New York between two trains on the elevated and exposed section of the Subway in the Bronx district, one train overtaking and running into a train in front. The impact was violent, and the first car of the rear train mounted the last car of the other, and hung suspended on the point of toppling over the side of the track. The motorman in the rear train was crushed to death in his compartment, and his body was so pinioned among the wreckage that it could not be removed. Fire broke out immediately after the collision, but through the efforts of the fire department it was soon extinguished. There were about 200 passengers in each train, and they all received a very severe shaking.

NOTES AND MEMORANDA.

IT is estimated that the total annual wage paid to British coal miners amounts to £6,000,000.

IN order to extinguish a mine fire by means of carbon dioxide gas, 7 per cent. of the mine capacity must be filled with the gas.

SUBJECTED to the action of liquid air, lead becomes elastic, and can be made to rebound or serve as a spiral spring during the continuance of this low temperature.

GOLD with coal associated has been found in the Batrina mine in Verespatak, Transylvania. The coal, however, is found only in small amounts, and not in paying quantities.

WE hear of a discovery of monazite sand along the shores of the Parahyba River in the interior of the State of Bahia, Brazil. The deposits now exploited are all on the sea-coast.

SOURCES of supply of nitrogen in making cyanide are the products of the destructive distillation of shale and coal in mineral oil and gasworks. Atmospheric nitrogen promises to be an important source in the near future.

TO restore lustre to tarnished aluminium it is sufficient to immerse it in water slightly acidulated with sulphuric acid. To small articles of aluminium a soft brush may be applied. For the bath, water with a little carbonate of soda will suffice.

ACCORDING to the *Revue des Prod. Chim.*, the Union Resinera Espanola produced last year 3982 tons of turpentine oil, of which about 2490 tons were exported, principally to the North of Europe and Switzerland. Of the 14,601 tons of resin produced by this company during the same period 3535 tons were exported, mainly to England.

ACCORDING to the *American Machinist* the greatest single consumption of brass is for condenser tubes; a battleship alone having from 30,000 lb. to 40,000 lb. of condenser tubing in it; and owing to the corrosive effect of sea water this tubing must be continually replaced. The material used is usually either Muntz metal—60 per cent. copper, 40 per cent. zinc—or else a mixture of copper, 70; zinc, 29; and tin, 1.

AT the end of 1906 the Imperial Chinese Telegraph Administration had a system length of 22,419½ miles, with 34,473½ miles of wires and 946·11 nautical miles of submarine cables. Offices numbered 379, of which 62 were open for day and night service and 317 for day service only. The number of instruments in actual use was 768. The staff of the head office in Shanghai numbered 67 and the general staff 3175, while inspectors, linesmen, &c., totalled 2400.

INVESTIGATIONS are proceeding on the suitability of Indian bauxite for the manufacture of alumina, the utilisation of by-products in coke making, the ores suitable for the smelting of copper and the manufacture of copper sulphate and sulphuric acid, the question of importing the richer and purer ores of iron, and the manufacture of iron and steel in India, the comparison of Indian manganese ores with those received from other parts of the world at the steel works in the North of England, &c.

LIGHTHOUSE construction is being conducted under great difficulties at the Ar-Gazeck reef on the French coast near Ushant. The late Eugène Potron left £16,000 towards the construction of this light, which the Government undertook to build. During 1904 the swiftness of the currents prevented more than 52 hours' work on the foundation, more than 206 hours in 1905, and more than 152 hours in 1906. During three years, therefore, only 51 days of eight hours were available for the work.

ACCORDING to the report of the Chief Inspector of Mines of India for 1906-7, the average number of miners working underground during the year was 48,508. The report says that Indians with some knowledge of mining, but better acquainted with agriculture, are finding their way to the South African mines in increasing numbers. This is accounted for by the inducements that are held out in the way of higher pay, shorter hours of work, and better and more liberal domestic accommodations. Upwards of 2300 such emigrants were employed last year in the Natal coal mines.

A STRANGE well exists at Riverside Park, Logansport, Ind. An 8in. pipe was first sunk about 80ft., and inside it a 5in. pipe was carried down lower. Fresh water from a limestone stratum comes up between the two pipes, while water which tastes and smells strongly of hydrogen sulphide comes up through the 5in. pipe from a lower stratum. The sulphur water flows at the rate of a gallon a minute from the drinking fountain over the well, while the fresh water flows with a somewhat smaller volume from a pipe about 20ft. distant. There is a similar well about 15 miles north of Cincinnati, but the latter is non-flowing.

THE life of wooden pipes made up of staves is, says the *Engineering and Mining Journal*, dependent upon the life of the bands holding the staves in place and resisting the internal pressure. By using galvanised wire bands deeply embedded in the wood and thoroughly and evenly coated with asphalt, the life is materially prolonged. Experience has shown that the pipe is still serviceable, even when the sectional area of the banding is reduced as much as 60 per cent. by corrosion. Iron pipe is frequently unfit for service when but 5 per cent. of the metal has been corroded. Wood pipe, when subjected to alternate wetting and drying, will quickly rot.

A WATER purification plant of special interest is now being built for the Union Stock Yard and Transit Company at Chicago. In order to increase its supply the company proposed to take water directly from the peculiarly foul dead-end of the Chicago River, known as Bubbly Creek, and to treat it by some purifying process. An experimental mechanical-filter plant was built, using sulphate of iron, sulphate of copper and caustic lime. On the basis of the results obtained, a plant of 5,000,000 gallons daily capacity is now being built. The Health Department, however, has made objections to the use of this water for any purposes besides washing and flushing.

STEEL struts and beams for lining tunnels have been used for twelve to fifteen years by the Susquehanna Coal Company in Pennsylvania. The consulting engineer of that company, Mr. R. V. Norris, designed a form of gangway support, consisting of posts of channels, with an I-beam cap. The members are put together with pins and wedges, and the posts rest on cast iron bases, which enable the whole construction to be taken down or to be adjusted very quickly. Some of these frames have been exposed to constant contact with mine water, but they show little sign of corrosion, although the only protection given them has been a good heavy coat of paint from time to time.

AN interesting phenomenon recently discovered by Marckwaldt consists of an alteration occurring in the colour of a body under the action of light, while the original coloration is re-established in the dark. The substances showing this phenomenon are very few in number, though, according to a communication by Prof. H. Stobbe at the recent Congress of German Naturalists and Physicists, the group of fulgides contains a number of substances of this kind. This phenomenon, called phototrophy, is of especial importance for chemical and physical science, as possibly embodying an immediate conversion of light waves into chemical energy. It might become extremely valuable for photography or for any other art utilising radiations of a similar nature.

MISCELLANEA.

THE streets of Berlin are cleansed by an 8 h.p. motor asphalt cleanser.

A NEW Bacteriological Department for India on a permanent basis has been sanctioned.

THE Olympia Motor Exhibition has just closed after being visited by close upon a quarter of a million people. There will be another show next November.

UNDER orders recently issued every enlisted man of the Russian army will be provided with a pocket compass, fitted with a luminous needle. Contracts have already been placed for 300,000 compasses to cost £80,000.

IN the course of a sham attack by submarines upon battleships at Toulon last Friday the submarine Bonite came into collision with the submarine Sirène, causing a panic among the crews of the two vessels. Though some damage was done nobody was hurt.

THE *Börsen Courier*, of Berlin, states that the Hamburg-America line has bought the patent rights of the Schlick gyroscope, and has ordered the Vulcan Works at Stettin to build an apparatus at a cost of £7500 for installation on the North Sea steamer Sylvania.

THREE grammes (about 46 grains) of radium have been made in the Vienna University laboratory. This is the greatest quantity yet produced, and to obtain it 10 tons of uranium pitchblende had to be employed. The process of obtaining the radium cost £2000.

ACCORDING to an authority, the first Automobile Show in Paris, held in some tents in the Tuileries Gardens, attracted 328 French and 12 foreign exhibitors, the value of their exhibits being about £150,000. At the last Salon there were 1225 exhibitors, of whom 1025 were French.

THE East Riding of Yorkshire County Council have appointed a deputation to wait upon the President of the Board of Trade with reference to the new regulations affecting weights and measures. The East Riding, being strictly an agricultural district, the regulations, which involve a considerably increased expense, are not viewed with approval.

OVERGATE was on the 13th inst. lighted for the first time with electricity. The old gas lamps have been discarded, and the new light introduced with effects which were universally regarded as satisfactory. The new lamps have been so arranged that the light is diffused from the centre of the thoroughfare overhead, and the latest specially prepared carbons have been introduced.

IN connection with the Austrian governmental establishment for the preparation of uranium products there has been built in Joachimsthal, Bohemia, a laboratory for working up radio-active substances found in the tailings and by-products of the uranium minerals. There will also be erected a bathing establishment, where the radio-active mine water will be used for healing purposes.

AS we go to press we learn with regret that an accident, attended with fatal results, happened late yesterday afternoon in connection with the widening operations at Blackfriars Bridge. One of the caissons was being lowered into position, when something gave way and it dashed into the river. As a result, we gather that at least seven men were injured, most of them seriously. One has since died in the hospital, and one is reported missing.

WE are informed by Mr. James Halcrow, of 18, Coleman-street, that the Nuernberg gas engine at the Bargoed colliery, which was described in THE ENGINEER of May 24th last, has now been running continuously for six months—Sundays excluded—has given on an informal test a consumption of 9750 B.Th.U. per brake horse-power per hour. The engine develops 1200 brake horse-power at 100 revolutions per minute, and is driven by coke-oven gas.

THE new Rangoon port wharves, which were opened by the Viceroy of India last Friday, are a portion of a scheme involving expenditure of 130 lakhs of rupees. A river improvement scheme is now to be proceeded with at a cost of 125 lakhs of rupees, of which the Imperial and Provincial Governments contribute 50 lakhs. If the scheme proves successful, a channel will be secured enabling the largest vessels to enter at the lowest state of the tide.

AN exhibition of cement and cement products is to be held at the Coliseum, Chicago, December 17th to 21st, next. It will include machinery used in connection with cement and concrete work, engineers' and architects' plans of structures, technical literature, and the work of testing beams, &c., of reinforced concrete. Several engineering and technical schools are expected to contribute to this last class of exhibits. This is the first annual "cement show," and is under the management of the Cement Products Exhibition Company.

AN analysis of the official return of casualties to ships in the British Navy, which has just been published, shows that out of a total of 81 recorded "casualties," as understood in the naval sense, there were 38 collisions and 31 groundings. The record of last year was 42 collisions and 32 groundings, and that of 1903 38 collisions. As ships now spend more time at sea than they used to, the risk of accident has been proportionately increased. That the liability to accident has not increased, the *United Service Gazette* regards as undeniable proof that the art of seamanship is not suffering.

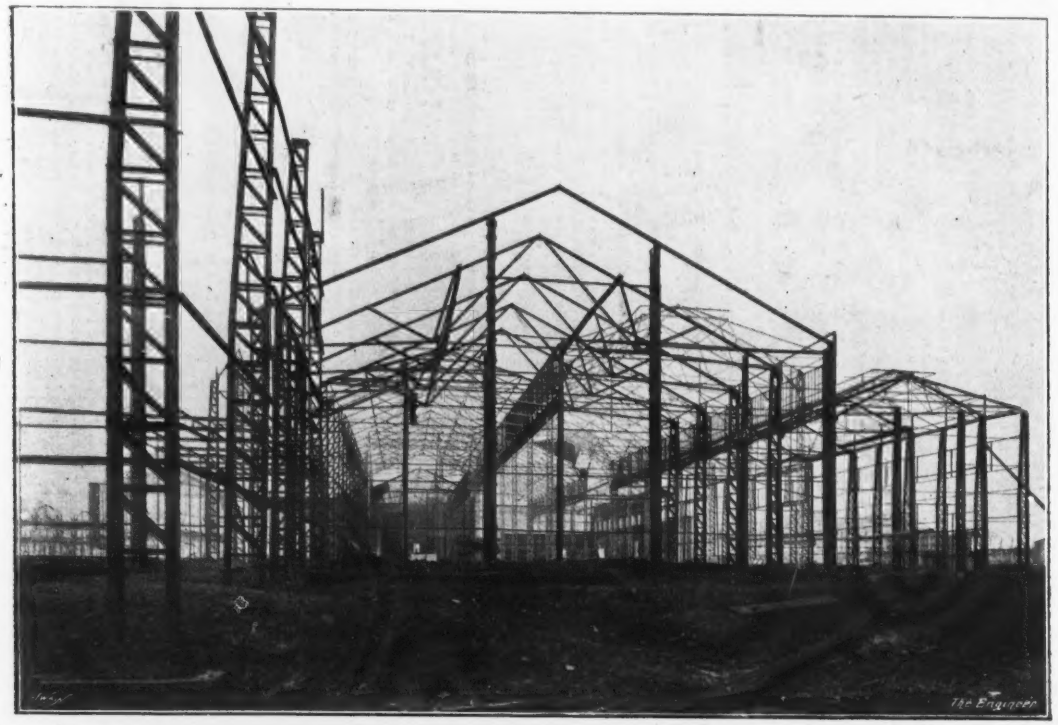
THE Upper India Chamber of Commerce has approved of the recommendations of the committee appointed to consider the amendment of the Indian Electricity Acts as to the desirability of all legislation in this connection being for the present assumed by the Government of India so as to ensure common standardisation of the regulations and terms on which licences are granted and uniformity generally, and as to the constitution of an advisory board for the settlement of technical problems. Further details in connection with the proposals of the amendment committee are under consideration by the Chamber.

THE quarterly report of the Amalgamated Society of Engineers shows that the total amount of its surplus funds is now £788,669, compared with £772,509 at the end of the previous quarter. The increase, however, is less by £5432 than in the June quarter. This, it is explained, is due to the increase of expenditure in respect to unemployment and increase of arrears, which now work out to an average of 5s. 7¾d. per member. In unemployed benefit £20,918, or 4s. 4½d. per member, has been paid; in sick pay £13,618, or 2s. 11d. per member; in superannuation £32,598, or 7s. 0½d. per member; and in funeral benefit £3243, or 8¼d. per member.

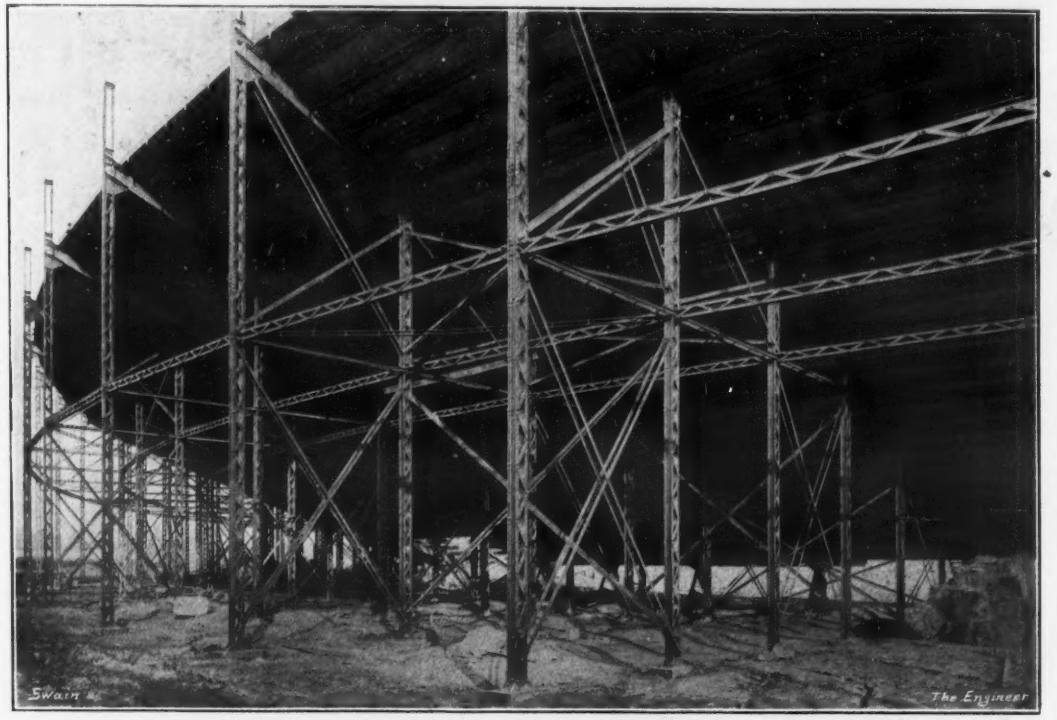
THE War-office have drawn attention to the fact that during the partial mobilisation of the Portsmouth defences, which took place between August 28th and 31st, it was found that inexperienced telephone operators had great difficulty in keeping up communication between fortresses, owing to the noise from other instruments. The difficulty does not arise in exchanges or in posts where there is only one operator, though possibly several telephones. General officers commanding have been asked to take such steps to obviate this as structural conditions will admit, by isolating each operator, with his telephone, or group of telephones, in a separate compartment.

THE FRANCO-BRITISH EXHIBITION—BUILDINGS DURING CONSTRUCTION

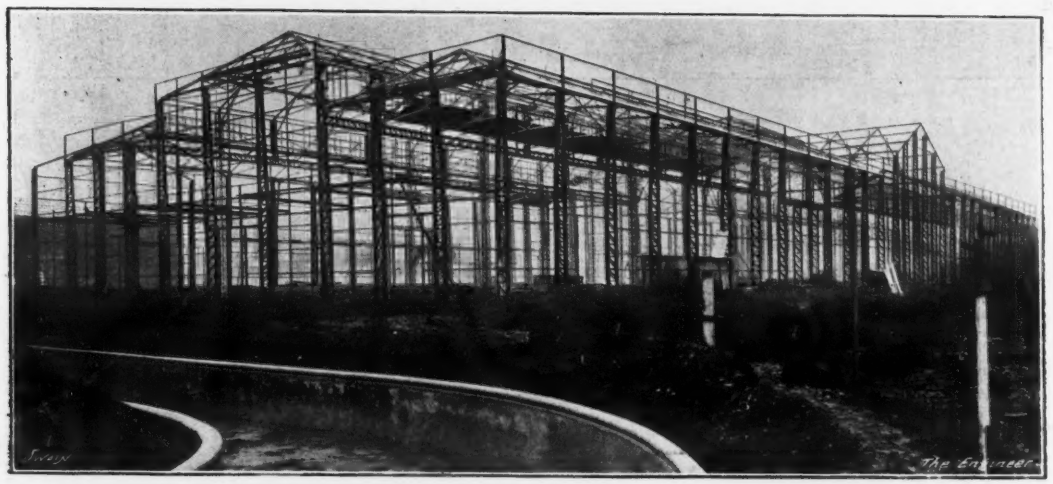
(For description see page 548)



FRAMEWORK OF INDIAN COURT



UNDERSIDE OF STADIUM SEATS



ONE ARM OF THE INDIAN COURT

END OF ONE ARM OF MACHINERY HALL

FOREIGN AGENTS FOR SALE OF THE ENGINEER.

AUSTRIA.—F. A. Brockhaus, *Seilergasse* 4, *Vienna.*
CHINA.—Kelly and Walsh, Limited, *Shanghai and Hong Kong.*
EGYPT.—F. Diemer, Finck & Beylaender, *Shepheard's-buildings, Cairo.*
FRANCE.—Boyveau & Chevillet, *Rue de la Banque, Paris.*
Chapelot & Cie., *Rue Dauphine*, 30, *Paris*
GERMANY.—Asher and Co., 5, *Unter den Linden, Berlin.*
F. A. Brockhaus, *Leipsic;* A. Twietmeyer, *Leipsic.*
INDIA.—A. J. Combridge and Co., *Railway Bookstalls, Bombay.*
ITALY.—Loescher and Co., 307, *Corso, Rome;* Bocca Frères, *Turin;* Ulrico Hoepli, *Milan.*
JAPAN.—Kelly and Walsh, Limited, *Yokohama.*
Z. P. Maruya and Co., *Tokyo and Yokohama.*
RUSSIA.—C. Ricker, 14, *Nevsky Prospect, St. Petersburg.*
UNITED STATES OF AMERICA.—International News Co., 83 *and* 85, *Duane-street, New York;* Subscription News Co., *Chicago.*
S. AFRICA.—Wm. Dawson & Sons, Limited, 7, *Sea-st.* (*Box* 489), *Capetown.*
Central News Agency, Limited, *Johannesburg, Capetown, Durban, &c., and at all their Bookstalls.*
J. C. Juta and Co., *Capetown, Port Elizabeth, Johannesburg, East London, Grahamstown.*
AUSTRALIA.—Gordon and Gotch, *Melbourne, Sydney, and Queen-street, Brisbane, &c.*
Melville and Mullen, *Melbourne.*
Turner and Henderson, *Hunt-street, Sydney.*
NEW ZEALAND.—Gordon and Gotch, *Cuba-street Extension, Wellington, and Bedford-road, Christchurch.*
Upton and Co., *Auckland;* Craig, J. W., *Napier.*
CANADA.—Montreal News Co., 386 *and* 388, *St. James-street, Montreal*
Toronto News Co., 42, *Yonge-street, Toronto.*
CEYLON.—Wijayartna and Co., *Colombo.*
JAMAICA.—Sollis and Cocking, *Kingston.*
STRAITS SETTLEMENTS.—Kelly and Walsh, Limited, *Singapore.*

Subscriptions received at all the Post-offices on the Continent.

SUBSCRIPTIONS.

The Engineer can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office on the following terms (paid in advance):—

Half-yearly (including double number) .. .. £0 14s. 6d.
Yearly (including two double numbers) .. .. £1 9s. 0d.

Cloth Reading Cases, to hold six issues, 2s. 6d. each, post free 2s. 10d.

If credit occur, an extra charge of two shillings and sixpence per annum will be made.

Foreign Subscriptions will, until further notice, be received at the rates given below. Foreign Subscribers paying in advance at these rates will receive The Engineer weekly and post free. Subscriptions sent by Post-office Order must be made payable to The Engineer, and accompanied by letter of advice to the Publisher.

Thin Paper Copies.		Thick Paper Copies.	
Half-yearly	£0 18s. 0d.	Half-yearly	£1 0s. 8d.
Yearly	£1 16s. 0d.	Yearly	£2 0s. 6d.

(The difference to cover extra postage)

ADVERTISEMENTS.

☞ The charge for advertisements of four lines and under is three shillings, for every two lines afterwards one shilling and sixpence; odd lines are charged one shilling. The line averages seven words. When an advertisement measures an inch or more, the charge is 10s. per inch. All single advertisements from the country must be accompanied by a Post-office Order in payment. Alternate advertisements will be inserted with all practical regularity, but regularity cannot be guaranteed in any such case. All except weekly advertisements are taken subject to this condition.

Advertisements cannot be inserted unless delivered before Five o'clock on Thursday evening, and in consequence of the necessity for going to press early with a portion of the edition ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of The Engineer.

Telegraphic Address, "ENGINEER NEWSPAPER, LONDON." Telephone—No. 13353 Central.

PUBLISHER'S NOTICE.

*** *If any subscriber abroad should receive* The Engineer *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the Paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

CONTENTS.

The Engineer, 29th November, 1907. PAGE

The Application of Highly Superheated Steam to Locomotives. No. VI. (Illustrated.) 531
Land Reclamation in Holland. No. II. 532
Our Mineral Statistics 534
The German Institution of Naval Architects. No. I. 534
Vanadium Steel in the United States 535
Tinning of Metals 535
International Electro-technical Commission 535
The Power Plant at Necaxa, Mexico 536
Rifled Artillery 538
The New Union Station at Washington. (Illustrated.) 539
The Future Water Supply of London. No. I. 542
Railway Matters 543
Notes and Memoranda 543
Miscellanea 543
Leading Articles—The Port of London 545
Future Water Supply of the Metropolis—Friction and Lubrication 546
Gas Engine Cylinder Temperature 547
Literature 547
The Franco-British Exhibition. (Illustrated.) 548
Friction and Lubrication. No. I 550
Clyde Improvement and Development 551
Obituary 551
Aberdeen Sewage 551
Tramway in North-West London 551
Letters to the Editor—Strength of Rings—British and Continental Steel Castings—Locomotive Engine Driving 552
The Institution of Civil Engineers 553
Some Comparisons between French and English Artillery .. 553
Naval Engineer Appointments 554
The Iron, Coal, and General Trades of Birmingham, Wolverhampton, and other Districts 554
Notes from Lancashire 554
The Sheffield District 555
North of England 555
Notes from Scotland 555
Wales and adjoining Counties 556
American Notes 556
Personal and Business Announcements 556
Notes from Germany 557
British Patent Specifications. (Illustrated.) 557
Selected American Specifications. (Illustrated) 558

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

F. H. (Ealing).—The greatest pressure is to be obtained by air pumps, and there is no limit to the pressure that can be produced, save the weakness of the material or defects of manufacture. There are plenty of other ways of getting a moderate pressure, say, up to 50 lb., and if you will say what pressure you require we shall be glad to advise you further.

W. J. B. (Weymouth).—No doubt a very powerful clutch could be made in the way you suggest, butwe do not think your design differs in essentials from other hydraulically-operated clutches which have been proposed and tried. The objection to all clutches of this kind is that they involve the use of pumps or presses of some sort, and are, as a rule, more complicated than mechanically-operated clutches. Your drawings have been returned to you.

MEETINGS NEXT WEEK.

Civil and Mechanical Engineers' Society.—Thursday, December 5th, at 8 p.m., at the Caxton Hall, Westminster, S.W. Paper, "Retaining Walls," by Mr. A. T. Walmisley, M.I.C.E.

The Institution of Electrical Engineers.—Thursday, December 5th, at 8 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Ordinary general meeting. Paper, "Automatic Cab-signalling on Locomotives," by J. Pigg.

Society of Arts.—Monday, December 2nd, at 8 p.m., at John-street, Adelphi, London, W.C. Cantor Lectures: "The Theory of the Microscope," by Conrad Beck, F.R.M.S. Wednesday, December 4th, at 8 p.m. Ordinary meeting. "Old Age Pensions," by Sir Edward W. Brabrook, C.B.

Liverpool Engineering Society.—Wednesday, December 4th, at 8 p.m., at the Royal Institution, Colquitt-street, Liverpool. Ordinary meeting. Discussion on Mr. M. Kahn's paper, "A Review of Reinforced Concrete, its Theory and Practice," will be opened by Mr. Alaric Hope, Assoc. M. Inst. C.E.

The Institution of Civil Engineers.—Tuesday, December 3rd, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Paper, "Experiments on Wind Pressure," by Thomas Ernest Stanton, D.Sc., M. Inst. C.E. Friday, December 6th, at 8 p.m. Students' meeting. Paper, "Methods of Vaporising Liquid Fuels, used with Internal Combustion Engines, as Applied to Road Vehicles," by R. T. Deane, Stud. Inst. C.E.

THE ENGINEER.

NOVEMBER 29, 1907.

The Port of London.

The official notice foreshadowing Mr. Lloyd-George's proposals to reform the Port of London and to constitute a Port Commission has just been published. The Bill which the President of the Board of Trade will bring in next session will, no doubt, be based generally on the Parliamentary Notice, but the latter document permits considerable latitude in drafting the terms of the measure. It is impossible to anticipate the amount of opposition that will be offered to the Bill when it appears, but if it should follow closely the terms of the notice, there is no doubt many public bodies and interests will find fault with it. The notice foreshadows the constitution of an entirely new Port Commission, partly elective and partly nominative, which will supersede the existing Thames Conservancy and the Watermen's Company so far as the river below Teddington is concerned. As was pointed out by Mr. Lloyd-George in April last, at the time of the withdrawal of the Dock Companies Bill, the new measure will impose increased dues on both shipping and goods. This was to be expected, and, although some opposition to the proposal may be anticipated, it is inevitable The constitution of the Port Authority is also to be in accordance with Mr. Lloyd-George's forecast of last spring. Representatives of Government departments and local authorities are to be joined with members nominated or elected by interests concerned. Neither the particular bodies to be represented nor the numbers of the representatives are indicated on the notice, and for these particulars we must await the issue of the Bill.

The proposals which will be received with most criticism are those concerning the purchase and construction of docks. The Port Authority may purchase any or all of the existing dock undertakings, construct new docks, wharves, and warehouses, and may enter into working agreements with the companies. Power will be given to co-operate with other bodies in the construction of docks and the provision of other facilities. Such comprehensive powers in themselves are unobjectionable, but it is conceivable that they might, under certain circumstances, be used to starve out the existing dock companies, and to compel them to accept inequitable terms of purchase. By the construction of new docks, the cost of which is met by rate guaranteed stock, the Port Authority will be able to enter into competition with the companies on terms which may conceivably be unfair to the latter, and thus so reduce their earning capacity as to force them to accept the terms offered by the Commission. This undesirable contingency could, we think, be averted by the inclusion of clauses in the Bill defining the basis on which terms of purchase shall be arranged. It would appear from the notice that compulsory powers of purchase, as generally understood, are not intended. The acquisition of the existing docks by a strong, independent and efficient Port Authority on equitable terms is not a proposal open to serious objections, but it is manifestly unfair to make it possible for the old interests, representing something under £25,000,000 of capital, to be crowded out or starved by undertakings established under municipal guarantee. The same argument seemingly applies to the wharfinger interests. There appears to be nothing in the proposals to prevent unfair competition in this direction also.

As to finance, the main features of the proposed Bill are the provisions for raising funds for the improvement of the Port. We have already referred to the proposed dues on ships and goods. Such dues are already levied by the Thames Conservancy to provide the means of dredging the lower river. The London County Council will be authorised or required to guarantee the payment of interest on Port Stock issued by the Commission. As regards the dredging of the river, the funds required for this purpose are to be provided by the London County Council and the City of London or either of them. The Commission would, no doubt, reap some advantage from such guarantees if it came to purchase the existing dock undertakings; but, on the other hand, the principle of rate guarantee, and with it some degree of municipal control, is admitted. It is not, then, to be expected that the London County Council and the City Corporation will consent to guarantee loans without representation on the Commission sufficient to give some degree of control. But it is a relief to find that Mr. Lloyd-George does not propose to constitute the London County Council the authority for the Port, and in view of the statement made by him in Parliament months ago, such a proposal was not anticipated. The present Council does not desire the responsibility of controlling the affairs of the Port, and it may be that the terms of the Bill can be so arranged as to avoid an undesirable representation of the Council on the new authority. It is of the utmost importance that the Commission should not be unwieldy in dimensions. The nearer it approaches to the constitution of the Mersey Docks and Harbour Board the better. That body is exempt from any control by the Liverpool municipality. Unfortunately, the same condition of things seems to be hardly possible in connection with the future of the Port of London, but the London County Council as at present constituted is not likely to demand a representation on the Commission which would swamp other interests. The actual constitution is, however, not to be crystallised at once, and it is proposed that the Board of Trade shall continue to have some control over the Commission after its creation. It is to have power to amend the representation of authorities or interests on the Commission, and to prescribe or alter the qualification of electors and the number of members of the Commission.

So far as can be judged from the published notice, there is little in the general principles of the Bill against which serious objection can be urged. It is in the applications of these principles in the Bill itself that ground of objection must be looked for by parties concerned. It is to be hoped that Mr. Lloyd-George will be able so to elaborate the details of the Bill as to disarm much of the opposition which already threatens. Apparently the President of the Board of Trade intends to introduce his measure in the form of a Private Bill; by so doing he probably expects to obtain a better chance of getting the measure through Parliament in the next session than would be the case if the proposals were contained in a public Bill. We have often urged in these columns the need of improvement in the Port of London, and this need is becoming day by day more urgent. It will be deplorable if the matter is again deferred next year through lack of agreement, and unwillingness to sacrifice something for the benefit of the Port. No measure aiming at its improvement can become law without some degree of co-operation on the part of all interests concerned.

Whilst Mr. Lloyd-George is dealing with the question as a whole, the London and India Docks Company has given notice that it intends once more to promote a Bill for dealing with the Port of London question. The promoters think it well to be prepared with an alternative scheme should the Government's proposals fail by any mischance. The directors state that their plan "is to strengthen the Thames Conservancy, making it the paramount authority in the Port, but not to give that body power to own or provide any dock or river accommodation. In other words, we would maintain the present system

of private enterprise for the provision of docks and quays, a system deliberately laid down by Parliament for London one hundred years ago, and under which London has become the greatest port in the world. . . . This scheme would, we are convinced, prove a more economical and efficient method of dealing with the problem than any scheme for municipalising the docks or of working them in combination by a trust on the Liverpool plan." The proposed Bill will differ in some respects from that promoted by the dock companies last year, several details in the earlier Bill to which exception was taken having been amended. However, the new scheme, as sketched in the parliamentary notice, would appear to follow the lines of the 1907 Bill in its main outlines. Yet another proposal dealing with the Port of London will probably be submitted to Parliament next session. A scheme has been prepared for the provision of extensive deep-water docks above Tilbury by cutting off the channel of the river in the bend at Grays, converting it into a series of docks with extensive wharfage, and forming a new and straight channel for the tidal river across Swanscombe Marshes. The water area of the dockised section of the river is 920 acres. The promoters of this ambitious scheme estimate it to cost £5,000,000. The Thames Conservancy Board have also decided to promote a Bill next session having as its object the further improvement of the river by dredging, the facilitating of traffic thereon, and provision for the continuance of the additional tonnage dues. Altogether the Port of London problem will loom large in the next session of Parliament, and there seems to be a likelihood that a considerable step in advance will be made.

Future Water Supply of the Metropolis.

A REPORT of its Works and Stores Committee dealing with the future water supply of the metropolis was considered by the Water Board last week. This report puts forward in a particularly clear manner the present position of London with regard to its water supply, and gives an elaborate forecast of what may be expected to be the conditions obtaining some fifty years hence. We need not burden this article with details as to how the figures put forward have been arrived at. It will be sufficient merely to state what these figures are. To begin with, then, the average daily supply at the end of March last was just over 225 million gallons. The estimated population was then over 6,850,000. In 1960—to look on ahead some fifty-two years—with an estimated population of 16,286,000, and an average supply per head of 35 gallons a day, the amount of water required will be 570 million gallons per twenty-four hours. The problems which the Committee have set themselves to solve are how is this quantity of water to be procured, and when the present sources can be no further developed, in what direction are further supplies to be sought? No details as to how the gigantic figure of 16,286,000 persons has been obtained are given in this particular Report, but we go into this matter in another column. As to the amount of 35 gallons a head per day, we do not think that any exception can be taken to this. It was the figure proposed by the Balfour Commission and upheld by the Llandaff Commission. Sir Frederick Bramwell, in giving evidence before the latter, considered it "very ample." Mr. Charles Hawksley thought it might well be reduced in time to 25, though, on the other hand, Sir Alexander Binnie stated that he would prefer to make it 40. The balance of opinion, however, seems to be in favour of basing the calculations on 35 gallons per head, and this view is strengthened by the fact that the average of the averages for the years 1881 to 1907, inclusive, works out at 33·46 gallons a head. If error there be, therefore, it is hoped that it is upon the right side.

The questions then arise, how can the amount of water which will be necessary up to and including the year 1960 be provided for, and what will have to be done after that time? At present, of the 225 million gallons total, nearly 129 millions are taken from the Thames, over 44 million gallons from the Lee Valley, 51¼ million from springs and wells, and the remainder from gravel beds and wells. Now it may be said at once that it is not considered that a much larger quantity than is at present obtained is available from all the other sources outside the Thames. At present, roughly speaking, the amount of water from these sources is 96 million gallons. The most that can be expected is 120 million gallons a day. It is, however, quite another matter as regards the Thames. Here up to a daily limit of 450 million gallons, it is merely a question of providing sufficient storage. Estimates have been prepared to show that by making a progressive series of additional storage reservoirs in the valleys of the Upper Thames and its tributaries it will be possible to provide by the time 1960 is reached for a daily delivery of this amount. The gross total storage, in addition to that now in existence or authorised, viz, 7279·5 million gallons, would then have to be 54,059 million gallons. This represents a vast body of water, and could not, of course, be provided without a correspondingly large expenditure of money. It is, however, nothing in comparison to what would be necessary in order to providefor the supply of another 50 million gallons of water a day. This, for reasons which are too complicated to enter into here, but which we shall explain in a future issue, would mean that an additional storage of nearly 45 million gallons would be required, involving a capital expenditure of between thirteen and fourteen millions sterling. The Committee, therefore, consider that as regards additional supplies from the River Thames, the economical limit will have been reached by the year 1960. They are, however, emphatic that up to this limit the Thames should and must be drawn upon. To quote their own words:—"Too much emphasis cannot be laid on the fact that London is peculiarly fortunate in the possession of what is undoubtedly an exceptionally favourable source of supply in the river Thames, and we cannot for a moment suppose that the natural advantages which the metropolis thus possesses will be ever abandoned." The possibility of further increases in the population of Greater London have, however, to be faced. It has been shown that it is not possible to get more than 450 million gallons from the Thames, in addition to 120 million gallons from other sources—both per twenty-four hours. This represents just the 570 million gallons which it is anticipated will be required in 1960. In another fifty years the present sources of supply will be incapable of further expansion, while there is not sufficient evidence to the contrary to lead to the supposition that the population will not go on increasing in the ratio indicated above. The Committee, therefore, consider that earnest consideration should be given to the practicability of acquiring some supplemental gathering ground which would be available in case of need after the exhaustion of the present sources. They evidently have such a gathering ground in their minds, as they recommend that a sum of £1000 be provided for the elaboration of a scheme which has been proposed by the chief engineer of the Board.

From what has gone before, it will be evident that the Board is looking well into the future, and providing the estimate of their Committee as to the growth of population in the water area and of the possible storage available be correct, there is no doubt that within a measurable time London will have to look further afield for additional supplies. We are glad to see, however, that there does not appear to be any suggestion whatever that the supply from the Thames is to be abandoned. In fact, the proposals are quite in the contrary direction. In spite of what alarmists have been continually saying for years, the fact remains that the water supply given to the metropolis is and has for many years been excellent. In this respect the Board appears to keep up well the traditions of the old companies. Supplementing is a very different thing to supplanting, and we are of opinion that it would be disastrous financially to abandon the Thames as a source of supply—a view evidently held by the Board. There can be no two ideas, however, as to the benefits to be gained by increased storage. Not only is there a further body of water to draw upon, but the advantages from the point of view of purification to be obtained by storage are very great. This is a point which is not sufficiently realised. Harmful microbes cannot live long in large bodies of standing water which contain ordinary water bacteria. Moreover, there is considerable saving in the cost of filtration when the water has had time for the solids in suspension to be deposited. Of course, the proposals outlined by the Committee will cost money. As far as concerns the increase of reservoir capacity for the impounding of Thames water, however, the Board has every confidence that this can be effected out of revenue, and that there will be no call on the rates. The extra income from an increasing population will, it is anticipated, fully cover the expense of making extra reservoirs, though it is not, of course, likely that the additional gathering ground will be purchased without a further outlay. There is at present no intimation of how the necessary amount for this is to be procured.

Friction and Lubrication.

ON Saturday, the 23rd inst., Dr. J. T. Nicolson read a paper on "Friction and Lubrication" before the Manchester Association of Engineers. Dr. Nicolson holds so high a position that much is expected of him, and we find with a species of mild surprise that this paper adds very little to the existing body of information concerning friction and lubrication. The fact seems to be that a great gap still intervenes between laboratory experiments on friction and practical engineering. This is in no sense or way the fault of those who carry out experiments. It is the unavoidable consequence of the intrinsic peculiarities of the subject of inquiry. Whether Dr. Nicolson's paper is good or not, whether it is simply a theoretical disquisition of no particular value outside certain vaguely defined limits, or is a valuable addition to the literature of an important subject, must be settled by those who heard, and those who read it, each man for himself, according to his individual point of view. To us its principal defect is that it takes no notice whatever of multitudes of cases which occur in the everyday practice of the engineer; while it lays down with mathematical precision rules which can after all be of but limited application, as though they could be fitted indiscriminately to all sorts of conditions.

It does not appear that Dr. Nicolson has the results of any personal experiments of his own to set before the world. He tells us, indeed, that he has utilised the experimental results of Stribeck, Detmar, Heilmann, and Lasche, as well as those of Beauchamp Tower, Thurston, and others, "for the purpose of framing rules for the sizing of journals of the different types used in practice, and to prepare formulæ intended to give a better approximation to practical requirements of the most divergent kind that has hitherto been obtained." This is a very comprehensive claim, covering a great deal of ground. As a matter of fact, the paper is comparatively narrow in its range of application. In another page will be found the principal conclusions arrived at by Dr. Nicolson. If we extract the essence of them we shall see that, after all, they apply to only one class of bearing, that used in lathe headstocks and line shafting. He deals briefly with dry friction. After describing in graphic terms what it means under the microscope, he goes on to say "that such a process should be reducible to any regular system of laws is not to be expected. A complete molecular theory of matter would be required to rationalise the phenomena which occur." This is sound sense. He next proceeds to consider the part played by an unguent, and then gives the places where oil should be admitted to a bearing. His conclusions are very nearly identical with those of Beauchamp Tower. One of his most important deductions is that when a bearing runs at a very slow speed it is much more likely to heat than when it runs fast, because at the slow speed the oil will be squeezed out, its viscosity will be overcome, and it will not follow the journal round. Going on, he attacks the statement made in Unwin's "Machine Design," writing μ as the coefficient of friction, that whatever may be the diameter or length of the proposed journal, the value μ will remain constant, which means that the length of the bearing must increase with the load and the revolutions. But, says Dr. Nicolson, "as a matter of experimental fact, the coefficient of friction depends on speed, pressure, and temperature. If we consult the above text-book we shall find that the so-called constant β varies in value from 30,000 to 1,500,000! A good deal is thus left to the taste and discrimination of the designer." Dr. Nicolson holds that in a properly designed bearing the surfaces will not be in contact, and the only resistance to be overcome will be that required to shear the oil. From which we gather that he takes it as proved that the film of oil adheres to the bearing at one side and to the shaft at the other, and that it is torn in two in the middle of its thickness; we say "middle" because, so far as we can see, there is no reason why the plane of shear should be nearer the brass than the journal. This is very pretty, but is it not pure theory. Has anyone yet seen the film of oil "sheared?" It is, furthermore, an entirely different theory from that commonly accepted, according to which the oil molecules act the part of rollers or balls between the two surfaces. At first sight the reader may be disposed to assume that Dr. Nicolson does not think a long bearing is necessary, because, while he says that if the bearing gets hot the oil will lose its viscosity and be squeezed out, he goes on: "The attained temperature is, however, independent of the length of the bearing." He follows this, however, with the admission that "we know from experience that journals must be long for high speeds, and the conclusion just quoted seems at first sight to conflict not only with the text-books, but with practice, and so to be paradoxical," and he explains away the discrepancy by saying that to keep the bearing cool it must be long enough to reduce the load per square inch.

The paramount defect in all papers of this kind is that they argue from the particular to the general. Certain bearings are tested under certain conditions More or less definite results are obtained, and then the experimenter proceeds without delay to apply them all round. Thus it might very easily be deduced from Professor Nicolson's paper that pressures of between 100 lb. and 225 lb. per square inch are the most that can with safety be allowed. But in everyday life we find these loads easily exceeded. Take, for example, the journals of railway carriage and wagon axles. The bearing surfaces are strips of white metal about 3in. wide and 7in. long. There are literally millions of such bearings running daily at all sorts of speeds, and the heating of one is a thing scarcely ever heard of. There are more railway bearings in existence than all the rest of the bearings, if we except spinning mills, in Great Britain, probably several times over. They have no forced lubrication. Again, if we take roll bearings in steel mills, we find narrow strips of brass—white metal would be melted—whose load is not estimated in pounds per square inch but in tons. The experiments quoted by Dr. Nicolson have literally nothing whatever to do with such cases. Take, again, the heavy bearings of marine engines. It is known to all seagoing engineers that if their brasses are in contact with the journal all round, disaster will ensue. The best practice gives a contact of three-fifths of the total circumference. Here that which we gather from Dr. Nicolson's paper is essential to success, namely, the maintenance of a continuous film of oil all round the bearing, does not appear to exist. At all events, the conditions are quite different from those illustrated in his paper.

It is clear that Dr. Nicolson's standard of excellence is the reduction of power wasted in friction to a minimum. We fear that that is not the engineer's standard. That bearing will please him best which will run coolest with the least expenditure on oil. Thus, for example, a shaft may be run with sperm oil, let us say, and a minimum of power, but with the expenditure of a little more power the shaft may run equally cool with a cheaper oil—one harder to shear, let us suppose. Again, the objection to long bearings is almost wholly structural. We have seen long and heavy mill engine bearings which were a total failure until they were mounted in cupped pedestal blocks which permitted them to adjust themselves to the shaft. It is well known to practical engineers that a heavily loaded shaft will run cool, or heat according to whether it has or has not a little end play—a fact of great practical importance to which no experimenter seems to give sufficient, if any, consideration. Conversely, longitudinal friction may be almost annihilated by making the sliding bar revolve—a fact of which Mr. Wicksteed has taken advantage in the construction of testing machines, the hydraulic plungers of which move without friction in their leather collars because they rotate slowly.

If we have been read aright, it will be seen that our criticisms of Dr. Nicolson are mainly directed to the claims which he has made for his formulæ. Their utility is far less extended than he thinks. The title of his paper is misleading. It should have run "The Friction and Lubrication of Machine Tool Bearings and Line Shafting."

Gas Engine Cylinder Temperatures.

If there is one subject more than another in connection with the thermo-dynamics of the gas engine which continues to attract the attention of investigators, it is the measurement with precision of the temperatures which occur inside the cylinder during the combustion and expansion of the gases. Much—theoretically much, that is—hangs upon these temperatures being known, and every serious attempt to measure them deserves particular attention. The latest experiments have been made by Professors Calendar and Dalby, who, on the 7th of this month, presented a paper on the subject to the Royal Society. We shall in an early issue reprint the greater part of it, and it is sufficient at present to remark that the authors have endeavoured only to measure the temperature at a certain point in the cycle, and that they withdraw the pyrometric wire during the rest of the time. During the explosion it is not exposed, and thus a very fine wire can be used with safety. This is a method of measurement which promises to be of great practical importance. We hope, however, it may only be a stepping-stone to the development of a direct means of measuring the maximum temperature in the whole gas engine cycle—that is, not merely inferring it from a direct measurement of a lower temperature, such as the temperature of the charge at the moment compression begins; which is what is usually called the "suction" temperature. It is true that on the assumptions that no dissociation takes place, and that the specific heat of the products of combustion is constant, the temperature at any point of the stroke can be easily calculated from the indicator diagram if the suction temperature is known; but our knowledge as regards dissociation is still slender, and although great strides have recently been made in determining the variation of specific heat, the law of the variation is still insufficiently determined to enable the temperature to be calculated with certainty; and lastly, the diagram itself, if taken with a pencil indicator, is open to some doubt, especially at the higher pressures, from which the maximum temperature has to be calculated. The authors dwell on this latter difficulty, and took their diagrams with an optical manograph.

The following figures will be of some assistance in obtaining an idea of the reduction in the maximum temperature due to the increase of specific heat with temperature. In an ideal gas engine with no loss by radiation, or to the jacket, the maximum temperature would under certain conditions reach 3000 deg. Cent. abs., with constant specific heat, but, with increasing specific heat, according to the latest determinations, the maximum temperature would under the same conditions only be 2500 deg. Cent. abs. We can feel satisfied that no such temperatures occur in the cylinder of an actual engine, but as approximations it may be taken that on the constant specific heat assumption, if the maximum temperature is 2200 deg. Cent. abs., then with increasing specific heat the temperature would be lowered to 1900 deg. Cent. abs. The effect of dissociation would be to reduce still further this maximum temperature and to increase the temperature further down the expansion. It will be conceded, therefore, that as regards the higher temperatures in the gas engine cycle we are still very much in the dark. The great advantage of a direct method of measurement for these temperatures is evident, but the difficulties of establishing a suitable apparatus are enormous, if not impossible, with known thermometric methods. The platinum thermometer is the most promising arrangement, but if the wire is comparatively thick so as not to fuse, elaborate corrections have to be made, which bring in uncertainties as great as those existing in the results obtained by the indirect calculation method. A material with a higher melting point than platinum is therefore needed, but it must also have a definite law of variation of electrical resistance with temperature. Such a material does not appear to be known at present. Previous attempts to measure even the suction temperature with a platinum thermometer have failed because the fine wire was exposed to the maximum temperature also, and invariably fused before any reliable measurements could be made. Messrs. Callendar and Dalby's device to withdraw the wire during the period of high temperature by means of what they call a "thermometer valve" is of great ingenuity, and ought to yield valuable experimental results.

The paper is principally descriptive of the apparatus, and of a method of testing the platinum thermometer during the compression by running the gas engine by means of an electric motor. The conclusion come to is that the suction temperature can be measured to within 1 deg. Cent. The authors only give a summary of the results of a number of trials they have run, reserving further discussion until more complete data are available. In the second example—Fig. 11—the maximum temperature calculated from the measured temperature of the mixture—viz., 130 deg. Cent. at 260 deg. crank angle—is 2500 deg. Cent. abs. The calculation is made on the assumption of constant specific heat, but if allowance had been made for increase of specific heat the calculated maximum temperature would be about 2000 deg. Cent., and we believe the actual temperature was nearer this value than the former. In conclusion, it is interesting to note that the suction temperatures measured by the authors agree well with those obtained by the ordinary methods of calculation.

LITERATURE.

Handbook of American Gas-Engineering Practice. By M. Nisbet-Latta, Member of the American Gas Institute, Member of the American Society of Mechanical Engineers. London: Archibald Constable and Co., Limited. 1907.

American gasworks broadly differ from those of Europe in that the manufacture of carburetted water gas takes the place of the manufacture of coal gas. It is true that coal gas is made on some gasworks in the United States, but only to a relatively small extent, much as carburetted water gas is made on many English gasworks to supplement a general production of coal gas. English handbooks on gas manufacture until comparatively recently devoted no space to carburetted water gas processes, and even now they properly treat them as quite subsidiary to the methods for the production of coal gas. Mr. M. Nisbet-Latta, in the handbook before us, has essayed to provide his American colleagues with a practical book of reference which shall bear the same relation to American gasworks practice as the older English textbooks on gas manufacture bear to English practice in the gas industry. He confines himself, so far as manufacture proper is concerned, to carburetted water gas, reserving for any subsequent editions of his book which may be called for the treatment of other methods of gas manufacture. Naturally the work in its present form cannot, therefore, interest English gas engineers to the same degree as a new work of equal merit dealing with coal gas production. Nevertheless, so much carburetted water gas is now made on many English gasworks that the gas manager in this country is now expected to have a thorough knowledge of its mode of manufacture. It is, indeed, significant of the authority with which English gas men speak on this, to them, relatively new branch of gas-making that Mr. Nisbet Latta is content, when dealing with the examination of gas oils, to give an extract covering over five pages from a treatise by an English writer, and on other points he quotes freely from our text-books.

It must not, however, be supposed that gas engineers on this side of the Atlantic will find no matter of value which will be new to them in this American handbook. It would, indeed, be surprising if, with the advantage of writing in the country in which carburetted water gas manufacture originated and now predominates, Mr. Nisbet-Latta did not furnish us with much fresh information in regard to it. As a fact, however, his treatment of water gas manufacture is somewhat disappointing. He devotes 133 pages to it, and offers many hints, evidently drawn from practical experience, of the supervision of the operating of water gas plants, which will be useful to superintendents, foremen, and gasmakers. He does not, however, give an exposition of the process of water gas manufacture from which an engineer, who is called upon to study it for the first time, would gain a clear impression of the principles underlying it, or of the operating routine. Neither does he help the responsible engineer in charge of a gasworks equipped with water gas plant with authoritative statements as to the merits of different types of apparatus and modes of working, and the results which should be attained under varying conditions.

The second part of the handbook occupies about 130 pages, and deals with the distribution of gas. From this part also some useful hints may be drawn by English gas men, but as a whole the treatment scarcely applies to the conditions prevailing in this country. The author states, however, that it applies to every field of gas engineering, and not merely to water-gas supply. Yet we find the following statement as to gas pressure:—"Pressure can at all times be reduced through means of district or house governors, but the initial pressure is only increased by an elevation in topography, which is equivalent approximately to 0·1in. of water for each rise of 15ft. above the outlet of the holder." Incidentally remarking that this quotation affords a fair indication of the author's style, it is, of course, obvious to a gas engineer that the statement is misleading except in regard to the relatively dense carburetted water gas, which is never distributed in Europe without admixture with an equal or larger proportion of coal gas. The pressure of coal gas increases 0·1in. for a rise in altitude of only about 10ft., consequently the author's general statement would mislead a European student. The reader who is competent to detect the inapplicability of such data to other than American conditions should alone be trusted to use this portion of Mr. Nisbet-Latta's handbook.

The third and final part of the work comprises upwards of 200 pages of general technical data collected from a variety of sources. Most of them appear to be tolerably trustworthy, but there are some obvious blunders, as, for instance, on page 406, where 1016—and a long fraction—kilogrammes are said to be equal to 2204 lb. avoirdupois—which is approximately a metric ton of 1000 kilos.—instead of to 2240 lb.—the English ton. There is also some needless repetition of data in this part, which, however, will, we think, be that most esteemed by English gas engineers who may use the book.

SHORT NOTICE.

Krausz's Practical Automobile Dictionary. By Sigmond Krausz. London: Iliffe and Sons, Limited, 20, Tudor-street, E.C. Price 3s. 6d. net.—Since the advent of the motor car it has become necessary for persons engaged in numerous different callings to know something of engineering and engineering terms. This little book contains twelve thousand technical and other words employed in connection with motor cars and motoring. The names are given in English, French, and German, and they are arranged in three separate orders for the convenience of readers of each nationality. At the end of the book there are some useful tables relating to foreign weights and measures and money values.

ROYAL COMMISSION ON COAST EROSION.

In the course of his evidence before the Royal Commission on Coast Erosion and Reclamation, Mr. E. R. Matthews, of Bridlington, handed in a statement which is printed in an appendix to the first report of the Commission. Mr. Matthews was expressly thanked by the Chairman for the valuable facts contained in this statement.

Mr. Matthews now desires to say that a large part of the statement was, in word and substance, abstracted from a series of articles on "Coast Erosion and Protection"* which appeared in The Engineer of May 18th, June 1st and 15th, 1906, and he desires to express a full apology to the proprietors of The Engineer, to the author of the articles, and to the Royal Commissioners for his failure to acknowledge the source.

* The articles in question were written expressly for The Engineer by Mr. Nicholas G. Gedye.

THE FRANCO-BRITISH EXHIBITION.

From an engineering standpoint the construction of the Franco-British Exhibition, which is to be opened at Shepherd's Bush next May, has now reached an interesting stage, for the half-finished condition of the various structures enables the details to be examined to excellent advantage. When finished the Exhibition grounds will cover an area of 140 acres, and a large proportion of this space will be occupied by various buildings dedicated to the science, art, and industries of England and France.

The entrance hall is a structure of considerable size, and although it does not form an integral part of the Exhibition it is an expensive piece of work, and it will undoubtedly add very materially to the convenience of visitors to the Exhibition. It is virtually a passage about half a mile in length connecting the Shepherd's Bush terminus of the Central London Railway with the Exhibition in Wood-lane, so that visitors on arriving at Shepherd's Bush will be able to reach the Exhibition by the most direct route, and they will remain under cover throughout the whole of the distance.

The largest buildings on the Exhibition site are the Machinery Hall, the Agricultural Hall, the Indian Court, and the Stadium. Although these buildings are not notable for exceptionally large spans, they are interesting structures and they have been built on modern lines. The constructional work for the buildings mentioned above, and for a portion of the entrance hall, has been carried out by Messrs. Alex. Findlay and Co., of Motherwell, from the design of Mr. John J. Webster, M. Inst. C.E., of Westminster, the ornamental work being designed by well-known English and French architects. A plan of the Exhibition is shown in Fig. 1. The Machinery Hall covers an area of nearly 6½ acres, and consists of two main buildings running north-east to south-west, joined together at the south end by a building of similar construction, thus forming a U-shaped building in plan. Each side building is 661ft. long by 130ft. wide, the cross-building being 302ft. long by 310ft. wide, the building having been extended to satisfy the demands for space. An illustration on page 544 shows the end of one arm of the building, and the section of a portion of the building is also shown in Fig. 4.

The main side buildings are divided into three bays, having one central span of 50ft. and two outer spans of 40ft., this system having been adopted throughout the principal buildings. The outer columns are 28ft. in height from the ground line to the eaves, being extended to carry the ornamental screen. The outer columns are 37ft. in height from the floor lines to the eaves, the columns being spaced 13ft. 4in. from centre to centre in a longitudinal direction. The inner columns are spaced at a distance of about 26ft. 8in., the intermediate roof trusses being carried on a longitudinal girder attached to the inner columns. The outer columns consist of two channel bars 9in. by 3½in. and 2ft. wide at the bottom, tapering to 1ft. 1in. wide at the top, and braced with flat bars and angles on each side; the inner columns consist of four angle bars 2½ by 2½ spaced 1ft. 2in. apart, and braced diagonally with flat bars. The columns are attached to base-plates, and they are let into concrete foundations to a depth of 4ft. and bolted to the latter with bolts 1ft. 9in. in length by 1½in. in diameter.

In calculating the bending moment of the columns a wind pressure of 30 lb. over the whole surface of the side was taken, and a pressure of 40 lb. on the roof acting horizontally, this being reduced normally by the formula $U^1 = U \sin \alpha\, 1{\cdot}84^1 - \cos \alpha - 1$, where U^1 equals the normal component, U the pressure per square foot vertically, and α equals the angle of slope with horizontal.

The roof trusses are of simple form, the end bracing bar of the central span being extended to the columns to stiffen the structure laterally. The principals are braced horizontally for wind pressure. Steel framed side-lights are fixed along each side continuously for a depth of 8ft., and there are also clerestory windows 8ft. deep, running continously on each side of the centre spans. In addition to these lights the roofs are glazed with Mellowe's glazing for a width of 7ft. 9in. on each side of the side spans, and 10ft. on the centre spans. The remaining portion of the roof is covered with corrugated sheeting. The sides of the building are filled with breeze concrete, 3in. in thickness, attached to horizontal wall joists, 3½ by 1½, spaced from 5ft. to 6ft. apart. The breeze concrete forming the walls was built in between timber frames. Each roof has a raised lantern running the length of the building, with ventilating louvres at the sides, the top being covered with corrugated sheets, and at the centre of the main cross building there are high lanterns of special construction. There are also special constructions at the ends of the buildings adapted to suit the ornamental features attached to the buildings, the latter being of plaster of elaborate design.

Turning now to the Agricultural Hall, this consists of one main building 427ft. 6in. in length by 130ft. wide, with an annexe at each end 123ft. in length by 67ft. 6in. wide. The main building is for exhibits, and the two annexes for restaurants. There is also a kitchen attached to one of the annexes 123ft. in length by 13ft. wide.

In front of the main building and the annexes there is a circular loggia 14ft. wide, which is supported on ornamental columns, and is extended round the end of the annexes. In the centre of the main front over the main entrance a high ornamental dome and towers have been fixed. At the front end of each annexe ornamental towers are fixed at each corner. The roof trusses of the annexes are in one span of 67ft. 6in. The constructional work of the main building is similar to that of the Machinery Hall, so that it is unnecessary to enter into further details concerning it.

The Indian Court consists of two main buildings 400ft.

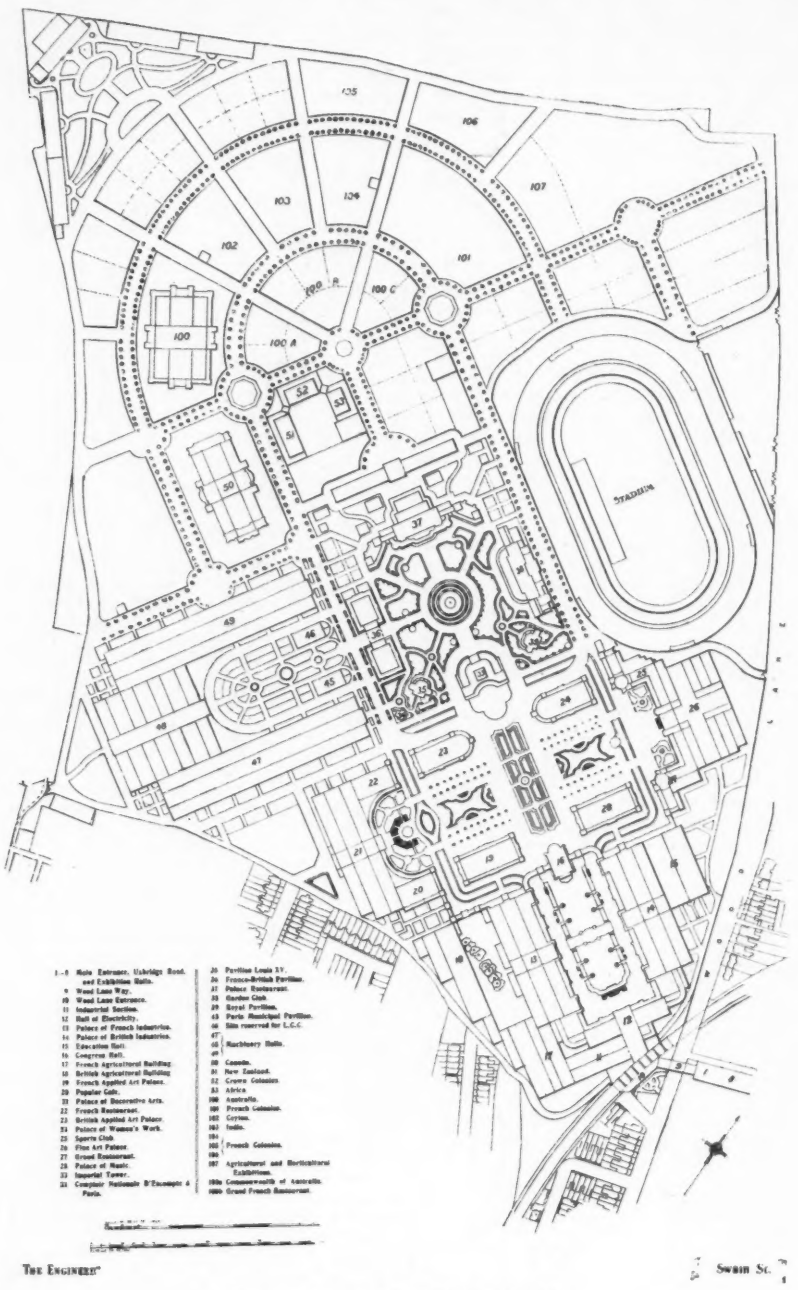


Fig. 1—PLAN OF EXHIBITION GROUNDS

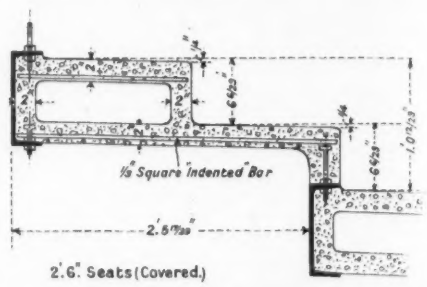


Fig. 3—STEPS OF STADIUM

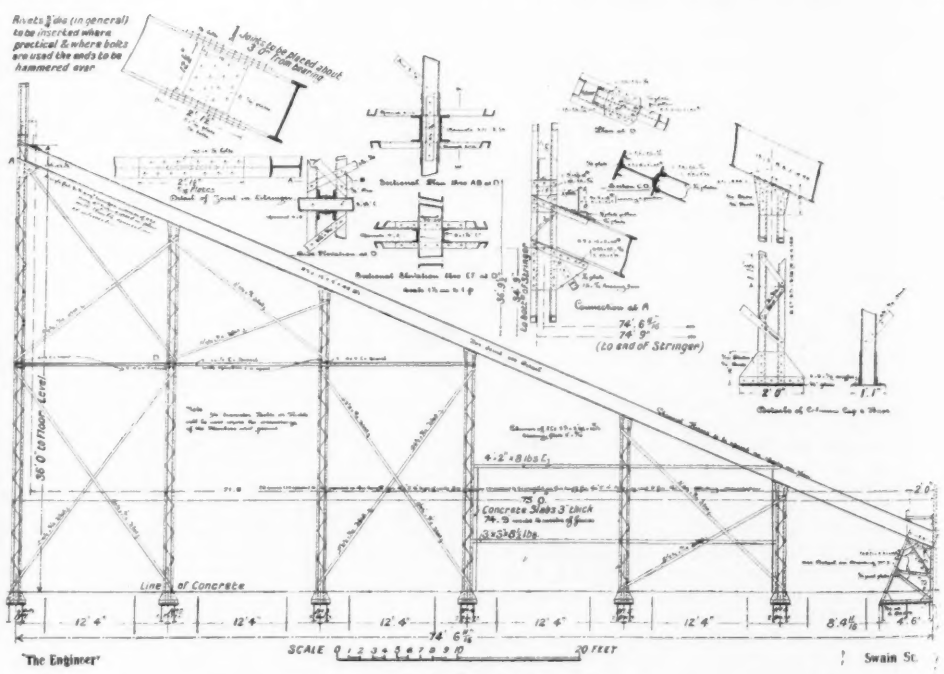

Rivets ¾in. (in general) to be inserted where practical & where bolts are used the ends to be hammered over
Joint to be placed about 3' 0" from centre
Line of Concrete
"The Engineer"
Swain Sc.

Fig. 2—FRAMEWORK OF SEATS IN STADIUM

long by 130ft. wide, spaced 252ft. apart and joined at the end with irregular shaped buildings, the whole block of buildings enclosing the space in which are the ornamental gardens with a large lake, as shown in the general plan. A loggia 14ft. wide is fixed in front of the building. The construction of the buildings which constitute the Indian Court is of similar design to that of the other buildings already described. Two views of this building as it now stands are given on page 544.

Perhaps one of the most interesting structures is the Stadium, in the centre of which the Olympic games are to be held. In Fig. 1 its position and general outline are shown, and in Figs. 2 and 5 side elevations, which show the general arrangement; a section of the roof is also given in Fig. 5, whilst an illustration shows the underside or rear of the Stadium seats. The building in plan has two straight sides with semi-circular ends, as shown in the general plan. The outside dimensions are 1000ft. by 594ft.; the seating and standing accommodation is 75ft. wide, and there are thirty-two tiers for seats and sixty-five tiers for standing, the spaces allotted for standing being at the circular ends of the building and the spaces for seating at the flat sides. The whole Stadium is capable of accommodating 75,000 persons. There is an open space 10ft. in width in front of the seats round the building, from which numerous entrances are provided from underneath the platforms. There is a cycling track

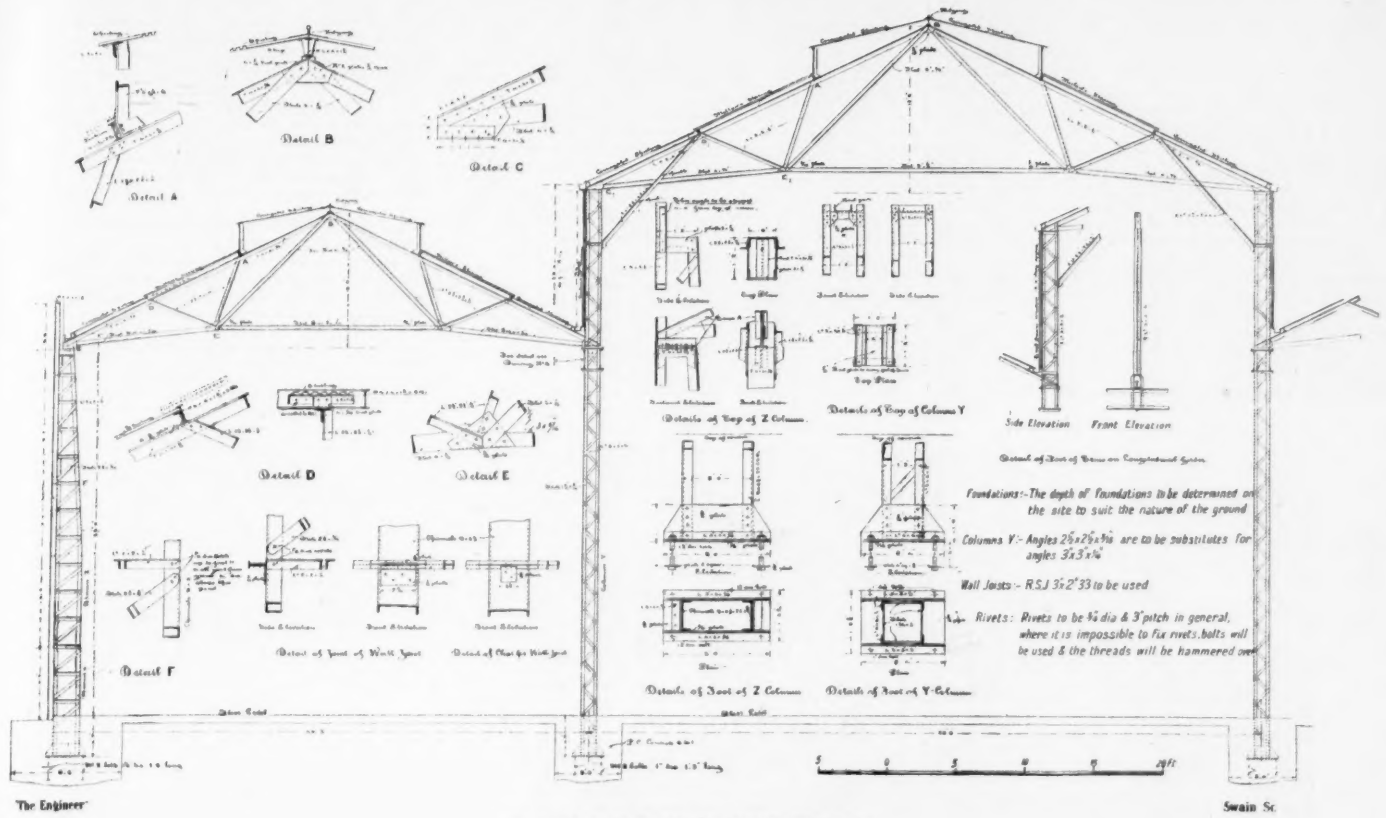

Detail A
Detail B
Detail C
Detail D
Detail E
Detail F
Details of Top of Z Column
Details of Top of Column Y
Side Elevation
Front Elevation
Foundations:-The depth of foundations to be determined on the site to suit the nature of the ground
Columns Y:- Angles 2½x2½x⅜ are to be substitutes for angles 3x3x⅜
Wall Joists:- R.S.J 3x2'33 to be used
Rivets:- Rivets to be ¾ dia & 3" pitch in general, where it is impossible to fix rivets, bolts will be used & the threads will be hammered over
Details of Foot of Z Column
Details of Foot of Y Column
Scale of Feet
0 5 10 15 20ft
"The Engineer"
Swain Sc

Fig. 4—PART SECTION OF MACHINERY HALL

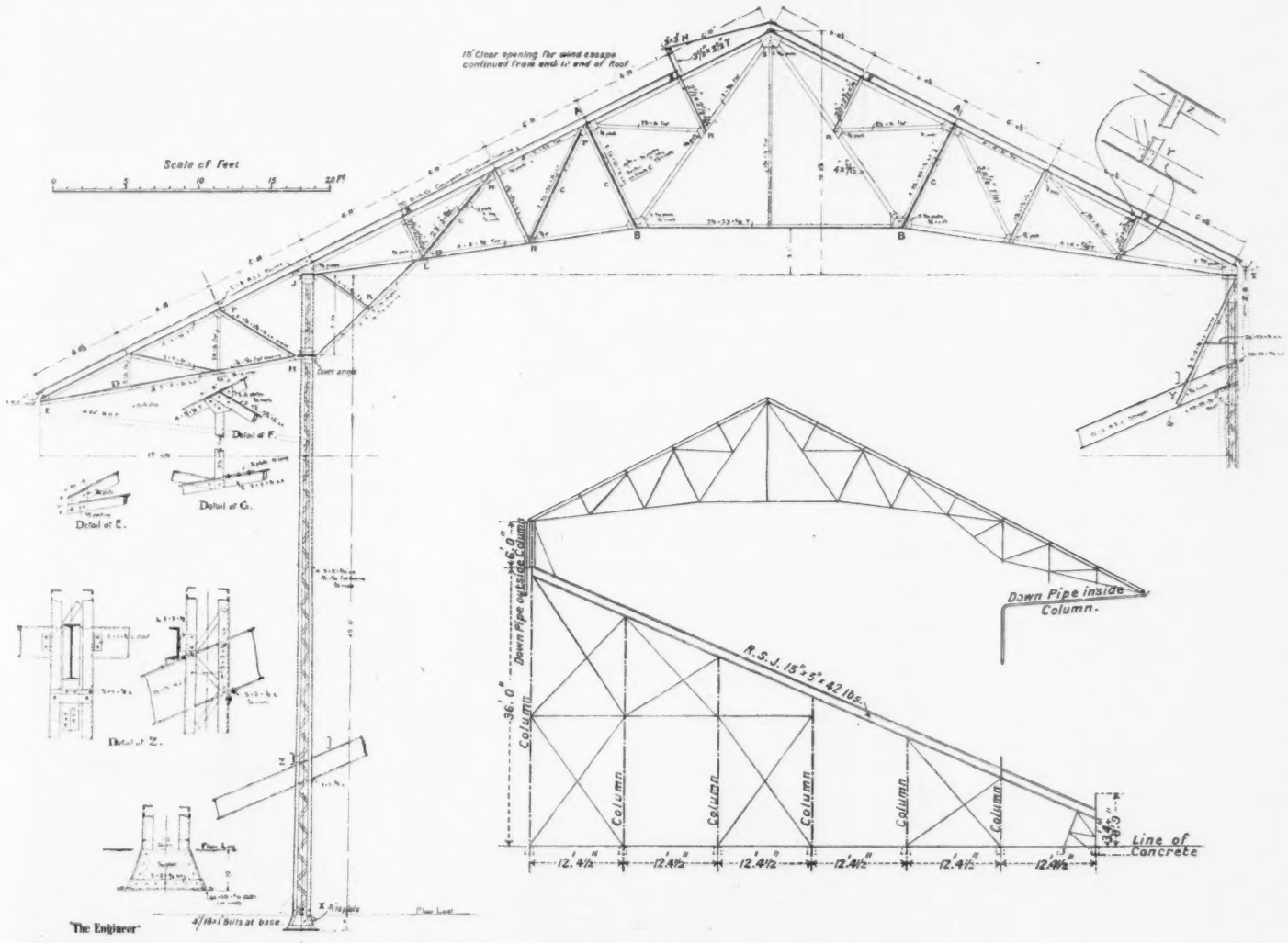


Fig. 5—SECTION OF STADIUM ROOF AND GENERAL CROSS SECTION

35ft. in width, ramped at the ends, a cinder running track 25ft. in width, and a swimming tank 335ft. in length by 50ft. wide.

The remaining space in the centre of the Stadium is covered with grass turf. The building is constructed with rolled steel joists, 15in. deep, spaced 20ft. apart, and supported by braced screen columns constructed with two channel bars, 5½ by 2½, braced on the sides with flat lattice bars. The columns are braced longitudinally and transversely with horizontal channels, and diagonal flat bars, and they are bolted securely to the concrete foundations. The risers consist of channel bars, 9 by 3, of varying weight, according to the span, the latter increasing from the front of the curved ends. They are spaced from 2ft. 4in. to 2ft. 6in., according to the position, and they are fixed to the rakers by means of forged stools. The platforms consist of reinforced concrete, averaging 2in. thick. The enclosed steel bars are of the indented type, ½in., square, spaced 12in. apart, the whole of the concrete being laid *in situ*. A section of the concreted portion of the work is shown in Fig. 3. Timber lath seats are to be fixed to the concrete. The side of the building where the seating accommodation is provided is roofed over with trusses, 61ft. 8in. in span, with an overhang of 17ft. 10½in. and the scantling is covered with corrugated sheets. The space underneath the platforms is utilised for offices, refreshment rooms, &c., the outside face being covered with plaster work of an ornamental character.

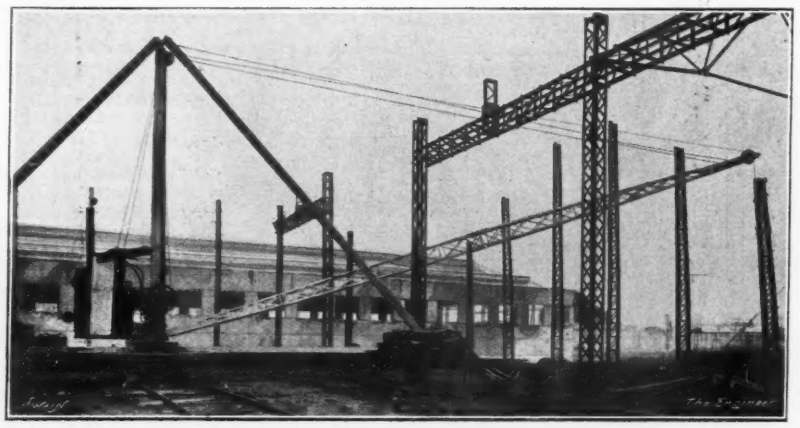


Fig. 6—DERRICK CRANE

We are informed that the work has been greatly facilitated by the use of the Scotch derrick crane which we illustrate in Fig. 6. This crane has an unusually large jib, with a 70ft. radius. It will be noticed that the crane is attached to a trolley running on rails. It has been used in the centre lines of the buildings, which enabled the whole of the material for the three roofs to be placed in position quite easily. The illustration shows the crane at work on the Agricultural Hall.

FRICTION AND LUBRICATION.*

By Dr. J. T. Nicolson.

No. I.

Introductory.

Engineers who have to spend so much time and thought on the elimination of friction in machinery in order to increase its efficiency may be expected to look upon it in the light rather of a bugbear which they would be better without. A moment's reflection, however, will show that life without friction is inconceivable! If all friction were instantaneously removed from the earth it is probable that every living creature would perish in the course of a few minutes. Everything in motion would persist in the same direction with the speed it had till it collided. Everything lying at rest upon a level surface could never begin to move. Wind would have no effect upon the sails of ships, nor would the propeller of a steamer have any power either to start or stop it. Every loose object on a slope of the earth's surface would slide down to the lowest point and on up the opposite side till it attained its initial elevation, when it would commence a return journey.

It would require the genius and pen of an H. G. Wells to predict what would happen to us in the first five minutes after friction ceased. As to what would be happening in the second five, a veil had better be drawn. Friction being an inevitable part of our environment, it is well for everyone, and essential for the engineer, to know something of the laws by which it acts. The present paper does not profess to give much attention to the phenomena of dry friction or the laws of the resistance of one solid moving over another. Its chief aim is to attempt an elucidation of the phenomena of the resistance offered to the relative motion of lubricated surfaces, and in particular of journals and bearings as used in engineering practice.

The experimental results of Stribeck, Dettmar, Heimann, and Lasche, as well as those of Beauchamp Tower, Thurston, and others, have been utilised for the purpose of framing rules for the sizing of journals of the different types used in practice. It is believed that the formulæ thus obtained give a better approximation to practical requirements of the most divergent kinds than has hitherto been obtained. In particular, the view commonly held that the length of a bearing should increase in proportion to the speed is shown to be erroneous. Descriptions of some of the modern methods of automatic and forced lubrication are given. The theory of the action of the loose ring and of the fast collar, as also that of the sizing of bearings for forced lubrication, have not been undertaken, the paper being already of sufficient length to exhaust the available space.

* Read before the Manchester Association of Engineers, Saturday, November 23rd. Abstract.

Part I.—Theoretical and Experimental.

(*a*) *Dry friction.*—In this case one solid substance rubs upon the other without the intervention of any unguent.

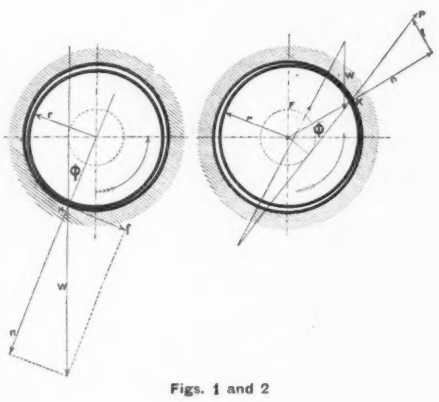
(1) Within certain small limits the frictional resistance may be said to be roughly proportional to the load acting; or to be independent of the extent of the surface over which that load is distributed; but when the pressure or load per square inch is large, the friction increases at a greater rate than the load; or, in other words, the coefficient of friction increases with the pressure.

(2) The coefficient of friction varies with the speed of rubbing. It is greatest when the motion is slowest; and when one body is just commencing to move relatively to another, we have what has been aptly termed "stiction," or the "friction of repose."

(3) The mutual friction of solids with no unguent interposed was found by Galton to diminish as the temperature increased. This is due to the fact that abrasion is easier at high temperatures.

(*b*) *Greasy friction.* — When some unguent is placed between the bodies, it may easily be imagined that some of the valleys are levelled up, and the intensity of the molecular action on the mountain tops is diminished. Thus we may have in this case any value up to that for dry friction. For iron upon iron, greasy and polished, Morin obtained the value 0·15 for the coefficient.

In the case of a greasy shaft lying in its bearings at rest, we find that the brass, being somewhat larger in bore than the diameter of the journal, is touched by the latter only along a narrow line at its lowest point. If now rotation begins, the journal rolls up the slope, just like a wheel, until the load on the bearing—supposed vertical—makes an angle equal to the maximum angle of repose ϕ with the journal radius drawn to the point of contact. The point of contact K—see Fig. 1—is then in a plane distant $r \sin \phi$ from that containing the centre of the bearing, and the journal slides on this point, or rather line, with the three forces f, n, and W in equilibrium. The law followed is that of so-called "dry friction," and the coefficient of friction $\mu = \tan \phi = \frac{f}{n}$ is identical with that found by Morin in 1833 for slightly greasy metallic surfaces, viz., from 0·12 to 0·18, or, say, 0·15 on the average.* The ratio $\frac{f}{W}$ is, of course, equal to sin ϕ, and being nearly the same as tan ϕ for such



Figs. 1 and 2

a small angle—8½ deg.—we have, for the frictional work done per revolution—

$$\text{Friction work} = \frac{2\pi r f}{12} = \frac{\pi d \mu W}{12} \text{ ft.-lb./rev.}$$

This is true even when there is plenty of oil, so long as the speed is small.

Take, as an example, the case of a spindle for a 10in. lathe running slowly with a weight of 3000 lb. carried by the front bearing, which is 3½in. diameter. Then the friction work per revolution is $0{\cdot}15 \times \pi \times 3{\cdot}5 \times 3000/12 = 413$ ft.-lb. per revolution.

If the cut were ¼in. × $\frac{1}{16}$in. on soft steel, the cutting force would be 3500 lb., and on a job of faceplate diameter—20in.—the useful work spent in cutting per revolution would be

$$3500 \times \frac{20\ \pi}{12} = 18{,}300 \text{ ft.-lb.}$$

The work lost in friction at the front journal is therefore

$$\frac{413 \times 100}{18{,}300} = 2{\cdot}26 \text{ per cent. of the useful work.}$$

A similar calculation for a lathe of 48in. centres would show a loss of about 10 per cent.

Such great frictional losses, which are constantly and inevitably happening when a lathe spindle, or other rotating shaft, runs slowly, even when abundantly fed with oil, impress upon us the necessity for using measures to preserve a separating film of grease or oil between journal and bearing, and not to allow them to run in metallic contact. This is much more difficult to accomplish at slow than at high speeds.

Fig. 2 shows the position of the point or line of contact between shaft and bush when the force acting has any other position, such as that shown by P. This position may always be found by drawing the resultant force from journal on bearing at a tangent to the friction circle, of radius $r \sin \phi$, in a sense tending to turn it in the direction of rotation.

Action of a Lubricant at Moderate Speeds.

When, as shown in Fig 1, the load on a journal acts vertically downwards, and the point of contact is at first at K, Fig. 1, near the bottom, there comes a time as the spindle speed goes on increasing when the oil is carried round with the journal, and forms a film separating it completely from the bush. The point of nearest approach between journal and brass is by this means shifted round to B, at the back of the bush, and in the same horizontal plane as the centre—see Fig. 3.

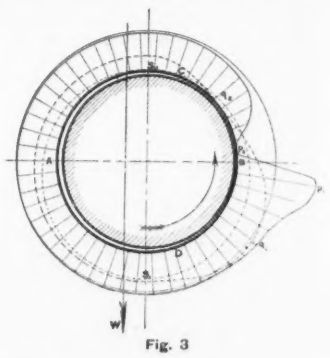


Fig. 3

The distribution of pressure all round the journal—the inter-space all being filled with lubricant—is shown diagrammatically in Fig. 3.

When the speed of rotation is slow the pressure is very great at p_1, just before B, the point of nearest approach, is reached, and falls to nothing at p_2 just after it is passed. It then soon rises and maintains a nearly constant value right round from C through A to D, after which it quickly increases to its maximum.

For greater values of the speed of rotation the maximum value of the oil pressure diminishes, and its position q_1 recedes from the neighbourhood of B; whilst at the same time, the position of the place where the oil pressure is nothing q_2 advances by an equal amount on the other side of B. The point of nearest approach of journal and brass still remains at B, however; but the journal becomes less excentric. If the speed were infinitely great the journal would run centrally in the brass, and the position of maximum and minimum fluid pressure would be vertically below and above the centre, viz., at s_1 and s_2, *i.e.*, in the line of the load—see Fig. 3.

The important physical results depicted qualitatively in this Fig. 3 enable us to fix upon the best position in the circumference of the bearing at which the lubricant ought to be applied.

With reference to the familiar instance of the front bearings of a lathe spindle we have, for the two cases of ordinary and forced lubrication, the following rules:—

Automatic lubrication.—If the oil is fed in by the ordinary cup and syphon, or by a ring or centrifugal method of supply, it should obviously be made to flow on to the journal at the place where the pressure is least; *i.e.*, at p_2, q_2, or s_2, Fig. 3—*ante*. It will not enter at p_1 or q_1 unless it is under a greater head than that of the oil film at these points.

The oil ways should therefore be fed from a point situated in the top rear quadrant of the bearing when the journal is loaded by gravity only, and the point should be further back the slower the speed. This applies, then, especially to large lathes. If the loading of the journal is principally due to cutting force acting upwards upon it, the feed should obviously be placed in the bottom front quadrant, and nearer the front the slower the speed of rotation. This meets the case of the smaller sized lathes.

The compromise ordinarily effected to enable the lubricant to enter, whatever may be the direction of the loading, is the simple one of fitting the oil cup on the top of the bearing. This seems almost the only thing to do in the case of automatic lubrication; but it is the correct position only when the resultant force upon the journal, due to gravity and cutting force, &c., acts nearly horizontally and from front to rear.

Forced lubrication.—When the lubricant is supplied by mechanical means at a fixed rate and at any required pressure, it must be fed in at the points—p_1 q_1—of greatest oil pressure in the bearing.

(*c*) *Frictional resistance due to viscosity.*—In describing

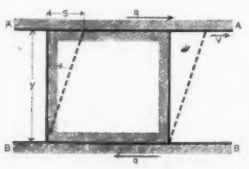


Fig. 4

the phenomena occurring when a journal rotates in a bearing, we have, so far, not alluded to the nature or magnitude of the frictional resistance experienced when there is an abundant supply of lubricant completely separating the former from the latter, and preventing any metal-to-metal contact.

In the case of the shearing of a solid, we know that Hooke's law, *ut tensio sic vis*, applies; so that if q, Fig. 4,

* See, *e.g.*, Mosseley's "Principles of Engineering," 1843, pages 149-155.

be the shear stress, and $\frac{s}{y}$ the shear strain, we write $q = G\frac{s}{y}$, where G is the modulus of transverse elasticity. But if the surfaces A A, B B are separated frnm one another by a liquid of thickness y, and A A moves with speed v relatively to B B, the resistance no longer depends upon the mere magnitude of the angle θ, but upon the rate of its increase with time. If a is the area of either liquid surface, the force required to maintain the steady speed v is

$$F = q\,a = \frac{k\,a\,v}{y}$$

where k is called the coefficient of viscosity of the liquid. [This coefficient is clearly that force which will move a unit area of surface with unit speed relatively to another surface from which it is separated by unit thickness of the liquid in question.]

A film of oil of uniform thickness y, all round a journal of diameter d and length l, and adhering to it and to the bearing surrounding it, will thus oppose a resistance to the rotation of the former with surface speed v of the amount

$$F = \frac{k\pi d\,l\,v}{y} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

In such a case the friction would not depend on the load, which does not appear at all in the expression; and it will be readily admitted that the force required to distort the oil film cannot depend on the fluid pressure to which it is at the moment subjected. The friction is governed only by the area of viscous fluid to be sheared, and the viscosity of the oil—*i.e.*, the kind of oil and its temperature, with which the viscosity greatly alters—and it also gets greater the smaller (y) the thickness of the film; so that if the journal is a close fit within its bush, the resistance to motion will be greater than if the fit is an easy one.

The term "coefficient of friction" denotes the ratio of the total resistance in the bearing due to the shearing of the lubricant, to the load on the journal; and although it has no physical meaning, it supplies a convenient and conventional method of discussing the results.

If F denote the resistance, and P the load, we have

$$\mu = \frac{F}{P} = \frac{k\pi d\,l\,v}{P\,y} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and if $\frac{P}{d\,l}$ be, as usual, denoted by p, and called the bearing pressure, or load per unit of projected bearing area, we see that

$$\mu = \frac{k\pi}{y}\frac{v}{p} = c\frac{v}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or the coefficient of friction would vary as the speed and inversely as the bearing pressure if the oil film were of uniform thickness all round, and the temperature of the lubricant were constant.

Referring to the dotted curves—thick lines—we observe that μ is not proportional to the speed in the actual experiments even when the temperature of the bearing is kept constant throughout.

We see that μ increases less rapidly than the velocity of rubbing when the speed is greater than about 20ft. to 80ft. per minute. This is due to the fact already mentioned that the difference between the actual temperature of the oil film and that of the bearing gets greater as the speed increases, so that, although the bearing temperature may remain the same throughout a series of experiments, that of the film of lubricant itself, upon which the value of k—the coefficient of viscosity—depends, does not. Thus μ falls away from the simple linear law the more the greater rubbing speed becomes.

These—as also Beauchamp Tower's experiments—show that the "coefficient of friction" in a lubricated bearing follows the law $\mu = \frac{c\,\nu\,v}{p}$ (instead of $\mu = c\,v/p$, as given above).

CLYDE IMPROVEMENT AND DEVELOPMENT.

The Glasgow Association of Students of the Institution of Civil Engineers has this session as its president Mr. William Murray Alston, M. Inst C.E., engineer-in-chief to the Clyde Navigation Trust, and at its first meeting, held last week, he delivered an opening address which, after dealing with subjects more particularly bearing on local Association affairs, treated exhaustively of the making of the Clyde, and the development of the port of Glasgow. He traced the various early methods of river improvement—dealing severally with the schemes and results of such engineers as Smeaton, Golborne, Telford, and Walker—and proceeded to deal more in detail with the system of steam power dredging which practically still obtains to-day.

The principal factor in the improvement of the river, said Mr. Alston, has been systematic dredging since the year 1824, when steam-worked dredgers were introduced, and by the scour due to the increased quantity of tidal water brought in. Up till 1862 the dredging machines discharged materials on to punts for towing in trains by steam tug to low-lying lands along the river banks, there to be discharged. The introduction of steam hopper barges in 1862 revolutionised this system, and the dredgers were altered for barge-loading. From 1862 to 1893, dredgings, carried by hopper barges, were deposited in Loch Long, 28 miles from Glasgow Bridge, at a place where there was a depth of about 35 fathoms. Owing to the objections taken by residents on the shores of the Loch this site had to be abandoned, and in 1893 a new depositing ground was authorised by the Board of Trade at the mouth of the Firth, three miles S.S.W. of Garroch Head, in 50 fathoms depth of water, and 46 miles distant from Glasgow Bridge. Owing to the exposed position of the new ground, and its greater distance from Glasgow, it was decided to build larger barges, and since 1893 ten of these have been provided, also three dredgers of the most powerful description, at a cost of about £287,000.

The general result of the improvement of the Clyde may be stated by saying that since 1755 the bed of the river has been lowered at Glasgow from 20ft. to 29ft.; and the river Kelvin to 30ft.; at Elderslie Rock to 36ft.; at Renfrew, 28ft.; at Newshot Isle, 28ft.; at Erskine, 25½ft.; at Dunglass, 26ft.; and at Dumbuck Ford, 27ft., making the bed practically level from Port Glasgow to Glasgow, while the river, which was at first only capable of navigation by boats drawing 4ft. of water, now permits of the largest vessels, drawing 28ft., trading with the port of Glasgow, and allowed the great Cunarder Lusitania, drawing 29½ft., to pass safely to sea some months ago.

The channel of the river requires vigilant watching, owing to the silting which goes on, due to *débris* coming down the Clyde, the Kelvin, the Cart, and the Leven. From the streets and sewers of Glasgow alone, hundreds of tons of sludge are daily sent into the river. Fortunately, there is a prospect of release from this evil in a couple of years, when the Glasgow Corporation sewage purification works for the south side of the river are completed. The saving in dredging which may follow the completion of the sewage works may be understood from the fact that there were carried to sea last year from the Dalmuir sewage works over 350,000 tons of crude sludge, which otherwise would have entered the river. The deepening and widening of the river is constantly going on, as the constantly increasing size and draught of vessels demand more depth and involves greater width. Dredging is now being carried to 23ft. below average low water at spring tides, or a depth of about 33ft. at high water at Port Glasgow and 35ft. at Glasgow.

The growth and development of the harbour of Glasgow has kept pace with the improvement of the river. The harbour now embraces the city portion of the river about 4½ miles in length, between Albert Bridge and the western boundary of the lands of Shieldhall, with the docks, quays, and other works within these limits. The first quay at Glasgow was built about 1662, and by 1792 the quayage amounted to 382 yards, with a water area of about four acres. Now the quayage is 15,002 lineal yards and the water area 291 yards. For many years riverside quays were sufficient for the requirements of shipping, and it was only when frontage became exhausted that docks were added, Kingston Dock being opened in 1867, Queen's Dock in 1877-1880, and Prince's Dock in 1893-1907. To provide specially for the mineral trade, and for transference of as much of it as possible out of Glasgow Harbour, a new dock authorised in 1899 has been constructed, in the burgh of Clydebank, about six miles below Glasgow. The western part of the work was opened last April by their Royal Highnesses the Prince and Princess of Wales, and received the name of Rothesay Dock. The building of the quay walls was completed last month. The dock has an area of 19⅜ acres and 2040 lineal yards of quayage.

Although Rothesay Dock was authorised in 1899, the demand for more accommodation became so apparent that in 1904 the Trustees obtained powers to construct basins and quays at Yorkhill, the last of the ground they possessed on the north side of the river within the city boundaries, and the works which are now in progress will provide 1148 yards of new quayage, with a depth at low water of 28ft.

The growth of the port of Glasgow is largely bound up with the prosperity of the city and surrounding districts. In 1810, when the harbour and river were placed under Trustees, the revenue was £6676, last year it was £557,861. The revenue has doubled since 1882, since 1873 it has trebled, and since 1867 it has quadrupled. In 1810 the quayage was only 382 yards and the waterway four acres, now the quayage is 17,042 yards and the water area 294 acres. Since 1810 the capital expenditure has been £8,759,000. The debts amount to £6,609,642. Last year 34,899 vessels, having a tonnage of 11,799,613 tons, used the port; and the tonnage of goods imported and exported amounted to 9,795,093 tons.

While much of the development has been very recent, provision is still being made for future expansion. The Trustees were authorised this session to construct about 530 yards of deep-water quayage at Meadowside, on the north side of the river, and on the south side there is much in reserve. In 1899 the burgh of Renfrew obtained power to enlarge their harbour by the construction of a dock, but in 1905 the Clyde Trustees purchased the Renfrew Harbour undertaking and all its rights, and the authorised dock was abandoned. At the same time the Trustees purchased from Mr. Speirs, of Elderslie, 110 acres of riverside ground. By this arrangement, and one with the Corporation of Glasgow for an exchange of site for the Southside Sewage Works, the Trustees became possessors of the whole river frontage from Linthouse to Renfrew, a length of over two miles, and about 400 acres of land. On this it may be possible to construct an amount of quayage equal to about one-half of the existing quayage.

TRAMWAY IN NORTH-WEST LONDON.

A further extension of the growing system of tramways belonging to the Middlesex County Council, but leased to the Metropolitan Electric Tramways, Limited, has lately been constructed, and only lacks the wires and posts to be ready for service. These, of course, will not take long to erect once the matter is put in hand.

The line in question carries on the Council's existing Harrow-road line from its terminus at what is called, apparently for lack of a more distinct appellation, the Iron Bridge, at Stonebridge Park, beyond Harlesden, and extends at present for about 1½ miles, to the bridge over the London and North-Western Railway at Sudbury Station. The Iron Bridge itself, upon which the cars at present stop, was re-built in 1905, with one 28ft. girder span and two flood arches in blue brick, of about 12ft. wide, large quantities of water coming down the river Brent after continuously wet weather. From here the wood paving of the line ceases, and granite setts are used instead. The roadway has been widened uniformly to 35ft., with a 10ft. gravelled footway on one side and space for a similar one on the other. Just over the first hill, below Oakington Farm gate, the level of the road has been much improved by embanking. At the bend by Wembley Hill Station wood paving begins again, and is continued so far as the tramway goes. A good deal of widening has been done about here between the 7th mile post from London and Sudbury Station, and is still in progress. Just off Blind-lane, for instance, the bank carrying the road is being widened by taking in portions of the gardens of the houses, whilst the curve is eased at the same time. At the London and North-Western bridge the tram stops, but there can be little doubt that its extension to Harrow, some 2½ miles further, is only a question of time. The railway bridge is extremely narrow, but could be widened on the north side without difficulty, and for the rest of the distance little or no alteration of the high road would be required. The portion already widened makes an extremely good road, though it has involved the sacrifice of many fine trees on both sides, and will, no doubt, soon be lined with rows of houses. At Sudbury and Wembley Hill, population has been fast increasing for some time, especially since the Great Central opened a station at the latter point. The widening of the road has been carried out by contract with Mr. Clift Ford, of Harlesden, the tramway being laid by Messrs. Dick, Kerr and Co. It is laid with 50ft. rails, 100 lb. per yard, made by the North-Eastern Steel Company, of Middlesbrough, and is a double line of railway gauge.

Just before reaching the Iron Bridge, coming from London, large car sheds have been erected in a field between the road and the London and North-Western Railway. It is called the Stonebridge Park depôt, and consists of three sections, each for four roads. The north, or closed end, is of corrugated iron, and the side walls of stock brick. The roofs are also of iron, and have two strips of glass on each side. They are about 130ft. long, with various offices on the side nearest the road. A double curve permits cars to go in or out in either direction, through two gates, each having the company's name and that of the depôt attached to it on a handsome sheet of hammered copper.

The Harlesden and Hammersmith tramway, stated in The Engineer of November 8th as soon to be constructed, will run off from the present Harrow-road line at the College Park Hotel, at the corner of Scrubbs-lane, close to Willesden Junction, and will afford a useful, if not very profitable, communication across the West of London. It has long been in contemplation, and would, perhaps, have remained so but for the coming of the Franco-British Exhibition at Shepherd's Bush next year. The main entrance to this will be in Wood-lane, along which the proposed tramway will run, but there is already a motor omnibus service which can bring people from much greater distances without changing than any tramway will be able to do. It was with a view to the construction of this line that the bridge over the Great Western, and the one under the London and North-Western Railway on Wormwood Scrubbs, have lately been re-built.

OBITUARY.

M. WALTON BROWN.

By the death of Mr. Martin Walton Brown, which occurred with terrible suddenness at his house in Newcastle-on-Tyne, on November 22nd, the Institution of Mining Engineers loses an indefatigable secretary, and the profession of coal mining one of its most useful representatives. Born fifty-two years ago, he served his time as a mining engineer at Killingworth, and subsequently proceeded to Hamsteels Colliery. On the retirement of Professor Ledebur he was appointed secretary of the North of England Institute of Mining and Mechanical Engineers, and at the same time secretary of the Institution of Mining Engineers, a federation for the purposes of publication of the "Transactions," &c., of various local mining institutes. He was also secretary of the joint committee of the Northumberland and Durham Coalowners' Association and secretary of the Board of Examination of the Newcastle mining district. He was the author of numerous papers on mining engineering, and was the recognised authority in this country on the scientific principles of colliery ventilation. He was an able editor, and raised the "Transactions" of his society to a high standard of literary excellence, and as secretary was untiring in his efforts for the welfare of the Institute, which, during his tenure of office, increased in membership from 1196 in 1891 to 3062 in 1906. He died in harness, for he left his office on the 21st, in his usual good health, and on the following morning, after breakfast, died quite suddenly. He leaves a widow, and a son and daughter.

ABERDEEN SEWAGE.

The first portion of an extensive improved sewerage system for the city of Aberdeen was formally put to work on the 13th inst. It forms part of a comprehensive scheme entered into under the Aberdeen Corporation Sewerage Act of 1898-9, and including the construction of a high-level outfall sewer, over three miles in length, part of the line being underneath the bed of the river Dee, and through the hill of Nigg, by tunnel, to an outfall below low-water mark at the foreshore of the bay of Nigg, a little to the south of Girdleness Lighthouse. The sewer is designed to discharge by gravitation, at Girdleness Point, the whole of the sewage of the city, with the exception of that of two low-lying districts—one at Abercrombie's Jetty, and the other near the Victoria Bridge, connecting Aberdeen proper with the Torry district. The discharging capacity is 82,000,000 gallons per day, or a quantity equal to the necessities of an estimated population of 270,000, at the rate of nearly 6½ times the daily dry-weather flow of sewage, which is approximately 45 gallons per head. All the storm water in excess of this quantity will pass by means of overflows to the rivers Dee and Don or their tributaries. The sewage from the two low-level areas is dealt with by sewers discharging into the river Dee and the tidal waters at the harbour entrance respectively. Another important section of the new sewerage system is in the northern district, and includes the construction of a high-level intercepting sewer four miles in length and joining the Girdleness high-level sewer. Up to date over £130,000 has been spent on the new works, which have occupied exactly six years in completion, and presented considerable engineering difficulties. This was so particularly in the tunnelling of St. Fittick's Hill, between the river Dee and the outfall at Girdleness, and in the construction of the foreshore portion of the works, which were frequently stopped by storms. The sea outlet is 21ft. below high-water mark, and pipes leading thither are protected by huge masses of concrete dovetailed into the rocks. The total cost of this section of the sewerage scheme, including the tunnelling of St. Fittick's Hill, has been about £80,000. The works were designed by Mr. William Diack, burgh surveyor of Aberdeen, and the contractor was Mr. Peter Tawse, of Aberdeen.

Society of Engineers.—The fifty-third annual general meeting of the Society will be held on Monday, December 9th, at the pociety's Offices, 17, Victoria-street, Westminster, S.W., for the Surpose of electing the council and officers of the Society for the year 1908. The chair will be taken at 6.30 p.m. precisely.

The Finsbury Technical College Old Students' Association hold their second annual dinner at the Criterion Restaurant on Wednesday, 11th December, 1907, at 7 p.m. It is hoped that all old students will endeavour to be present. Applications for tickets (5s.) may be made to Stanley E. Gritton, hon. secretary, Talfourd Cottage, Reigate, Surrey.

The Institution of Civil Engineers: Newcastle-upon-Tyne Association of Students.—The second meeting of the session will take place on Thursday, December 12th, at 8 p.m. prompt, in the lecture theatre of the North of England Institute of Mining and Mechanical Engineers, Neville Hall, Neville-street, Newcastle-on-Tyne. The subject of the evening will be a general discussion on the following:—"The Practical Application of Theory, its Uses, and its Limitations."

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

STRENGTH OF RINGS.

SIR,—I note in your issue of November 8th a solution to the above problem, given by Mr. G. J. Wells. Although Mr. Wells arrives at a correct result to the solution, the reasoning employed is in error. Considering Fig. 3 of his solution, it is stated that—

$$\frac{d\phi}{ds} = \frac{I}{R} = \frac{M}{EI}.$$

$\frac{M}{EI}$ does not equal $\frac{I}{R}$, $\frac{I}{R}$ being the initial curvature of the ring, but equals the change of curvature that takes place at the point under consideration when the ring is loaded.

Mr. Wells arrives at the correct result to the solution by stating that

$$\int_0^{\frac{\pi}{2}} d\phi = \text{zero},$$

which is obviously not the case, the value of the integral being $\frac{\pi}{2}$; his $d\theta$ and $d\phi$ as I understand represent the same quantity.

The following, I think, will show clearly the proof.

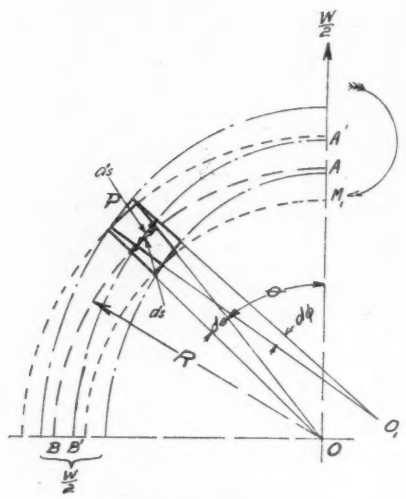
Let A B represent a quadrant of the unloaded circular ring, and $A^1 B^1$ its shape when loaded (exaggerated in diagram).

W = load on ring.

M_1 = bending moment at the point of application of load—*i.e.*, at A.

R = radius of the centre of section of the ring.

Consider the elementary length ds of the ring; in the unstrained



condition it subtends an angle $d\theta$, but when strained subtends the angle $d\phi$. Therefore if R_1 = radius of curvature of the element in the strained condition,

$$\frac{d\phi}{ds} = \frac{I}{R_1} = \text{curvature when loaded,}$$

$$\text{also } \frac{d\theta}{ds} = \frac{I}{R} = \text{curvature when unloaded,}$$

if M = bending moment at the point under consideration

$$\frac{M}{EI} = \text{change in curvature} = \frac{I}{R^1} - \frac{I}{R}$$

$$= \frac{d\phi}{ds} - \frac{d\theta}{ds} \quad \ldots\ldots\ldots\ldots \text{(i)}$$

A change has taken place in the angle between the faces at the ends of the element $ds = d\alpha$, say, where

$$d\phi - d\theta = d\alpha$$

Since the faces at A and B remain parallel to themselves when the ring is loaded, therefore the total change α over the quadrant is zero, and is exprressed by

$$\int_{\theta=o}^{\theta=\frac{\pi}{2}} d\phi - \int_{\theta=o}^{\theta=\frac{\pi}{2}} d\theta = \int_{\theta=o}^{\theta=\frac{\pi}{2}} d\alpha = 0 \quad \text{(ii)}$$

Since $ds = R\,d\theta$

from eqn. (i) $$\frac{M}{EI} R\,d\theta = d\phi - d\theta.$$

Mr. Wells shows that $M = \frac{W}{2} R \sin\theta - M_1$, substituting this value for M, and integrating between the limits $\theta = o$ and $\theta = \frac{\pi}{2}$, gives

$$\frac{R}{EI}\int_o^{\frac{\pi}{2}} \left(\frac{W}{2} R \sin\theta - M_1\right) d\theta = \int_{\theta=o}^{\theta=\frac{\pi}{2}} d\phi - \int_{\theta=o}^{\theta=\frac{\pi}{2}} d\theta = o$$

From this point the solution is deduced as shown by Mr. Wells.

Manchester, November 21st. R. W. BAILEY.

SIR,—I regret that Mr. Pardoe has entirely missed the point in my last letter. This was probably due to the brevity of my letter and to the assumption on my part that the diagrams were self-explanatory. This would have been a reasonable assumption if Mr. Pardoe had been able to follow the reasoning set forth in the solution sent by Mr. Wells. However, I will endeavour to make it clear to him.

A perfect knowledge of the state of stress in any material subjected to a load cannot be obtained with the most abstruse mathematics, and to experimental results we must always make the final appeal. The usual "theory of bending" adopted by engineers will, however, help us to obtain a close approximation to actual results.

My sketches were given not to show, as Mr. Pardoe suggests, the manner in which the ring ought to fail, but they were intended to show the differences between the two theories as given by Mr. Wells and Mr. Pardoe. In Fig. 1 the dotted line represents the distorted position of the ring.

Fig. 2 represents the left half of the ring. It will be seen that the ends A and B are constrained by molecular forces to keep horizontal, *i.e.*, the sections at A and B are capable of offering a resisting moment. This moment is denoted by "M."

The greatest bending moment will be at C, and equals $\frac{W R}{2} - M$.

Reference to the solution sent by Mr. Wells will show how the unknown moment "M" may be found, and hence the maximum bending moment, which will occur at C, may be determined. The

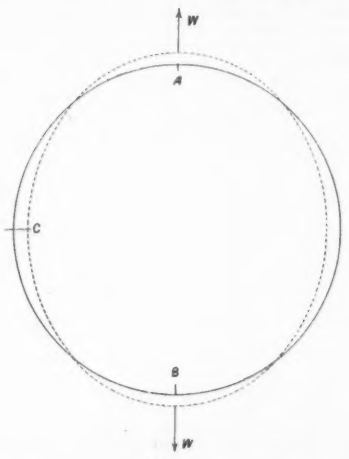


Fig. 1

second figure in my last letter was given to show the difference between the above result and that obtained by Mr. Pardoe. The latter correspondent has neglected "M" altogether, and has, therefore, assumed that the ends A and B are capable of being pulled out by the load—Fig. 3—without offering any resisting moment.

Mr. Pardoe does not follow the last paragraph of my letter—

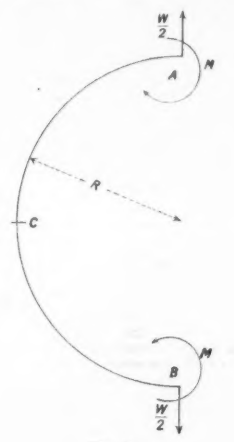


Fig. 2

"the place of application of the load is assumed incapable of resisting bending." This is the assumption made, not by me, but by Mr. Pardoe as shown above. The paragraph in my last letter was intended to show that Mr. Pardoe's solution failed because this assumption was made.

In dealing with the problem of an encastré beam the unknown fixing moment "M" is determined by certain conditions. Com-

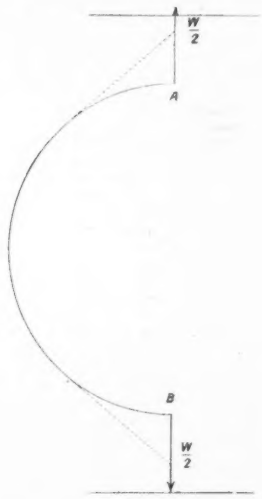


Fig. 3

pare this with the more correct theory of the ring as given by Mr. Wells.

In dealing with the problem of a supported beam, the value of "M" = o. Compare this with the theory given by Mr. Pardoe.

Mr. Pardoe admits the existence of "M" in his reasoning, but ignores it in his calculations. I would like to draw attention to what I consider a slight error in the proof given by Mr. Wells, which does not affect the result. $d\phi$ is given as the angle between the ends of the element of the ring considered, whose length is ds. I think this should be "change of" angle between the ends of the element when the ring is loaded and unloaded.

If $\frac{I}{R}$ = "unloaded" curvature at the point,

$\frac{I}{R_1}$ = "loaded" curvature at the point.

$$\text{Change of curvature} = \frac{d\phi}{ds} = \frac{I}{R} - \frac{I}{R_1} = \frac{M}{EI}.$$

Again, the element ds subtends an angle $d\theta$ at the centre, and not $d\phi$.

With apologies for having taken up so much of your valuable space.

Preston, November 25th. E. C. MOYLE.

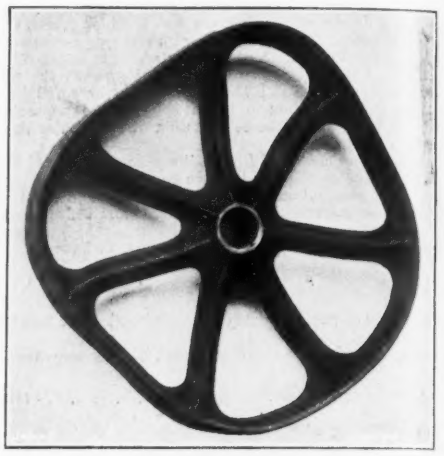
[May we ask correspondents on this and other subjects to make sketches to accompany their letters on separate sheets of paper, and on one side only? They would thereby greatly facilitate reproduction.—ED. THE E.]

BRITISH AND CONTINENTAL STEEL CASTINGS.

SIR,—Having had a good deal of experience with light and medium weight steel castings from 2 lb. up to 5 cwt., my opinion may be of some interest.

Castings which are not subject to wear and rubbing, but which have to resist vibration, and are subject to shock, should be ductile, free from blow holes, and, to facilitate machining, free from hard spots. Castings of this description can, I find, be obtained from Continental steel works, at a moderate price, of such quality that not more than 2 per cent. have to be rejected after machining. By paying about 50 per cent. more castings can be obtained which are absolutely perfect, without hard spots, blow holes or other imperfections—in fact quite equal to forgings.

The enclosed photograph shows a steel wheel of which the tire, in



CAST STEEL WHEEL

running a distance of 15,000 miles, wore down from an origina thickness of 1¼in. to $\frac{5}{16}$in., and which was then taken off, and as an experiment distorted in a hydraulic press, cold, to the shape shown without showing any signs of cracking. This wheel was made by an eminent Continental firm, and is, I think, a good example of the perfect steel casting.

Castings which are required to have superficial hardness to resist wear and tear, as, for instance, gearing with cast teeth, can be obtained better in this country, but they usually suffer from hard spots, which make the machining operations difficult.

Richmond, November 23rd. HENRY A. NEAL.

LOCOMOTIVE ENGINE DRIVING.

SIR,—If "An Express Driver," whose letter appears on page 518 of your last impression, had read my communication with a little care, he would have seen that his criticisms are unjustifiable. He says that an inexperienced man would know nothing about the signals. Quite true. I never said that he would. Further, neither perhaps would his fireman. Perhaps a few words stating what has actually happened may clear up matters for "An Express Driver." Some time ago there was a strike on an important main line in one of our Colonies. Engine drivers and firemen with no experience of locomotives, were put on engines. On each footplate was also put a guard who was quite familiar with the signals. He instructed the driver. The number of trains and the speeds were reduced. The strike was all over in a week. There were no mishaps.

As to yard work, any groundsman could easily keep an inexperienced driver straight.

If "An Express Driver" had had as wide a footplate experience as I have had, he would know that the going round an engine of which I have spoken is a very common practice, particularly with careful drivers who are not timorous.

If he will read once more what I have said, he will see that I have specially excepted what are known as "fliers." These trains are driven by the very best picked men. Possibly "An Express Driver" is one of them; possibly he is not. There is a wide difference between riding a race and driving a carriage and pair. If there was a strike the jockeys would go to the wall; not the coachmen. There are a thousand coachmen to be had for one jockey.

November 26th. YOUR CORRESPONDENT.

ROYAL METEOROLOGICAL SOCIETY.—The first meeting of the session was held on Wednesday evening, the 20th inst., at the Institution of Civil Engineers, Great George-street, Westminster, Dr. H. R. Mill, president, in the chair. The meeting was largely devoted to the consideration of the reports on the results obtained by the balloon observations made in the British Isles, July 22nd to 27th last. The International Aëronautical Commission has for some years set apart the first Thursday in each month for the ascent of kites and balloons, but at last year's conference it was decided to make a special effort to obtain information on a series of consecutive days, and the last week in July was finally decided upon for the purpose. Twenty-five balloons with registering instruments were sent up in England and Scotland during the week, under the direction of Mr. W. H. Dines, F.R.S., at Pyrton Hill, Oxon, and at Crinan, on the West Coast of Scotland; of Mr. J. E. Petavel, F.R.S., at Manchester University; Captain C. H. Ley, R.E., at Sellack, Herefordshire; and Mr. C. J. P. Cave, at Ditcham Park, Petersfield. Fourteen of the registering instruments have been found. Professor W. E. Thrift also sent up a number of pilot balloons from Dublin. Nearly all the balloons drifted to the eastward, but several which reached a fair height fell within 20 miles of their starting point. The heights ranged up to over 12½ miles, the average being about 7½ miles. The records showed that above 7½ miles the temperature remained almost unaltered with change of height. A paper giving a discussion of the meteorological observations at the British Kite Stations, session 1906-1907, by Miss M. White, Mr. T. V. Pring, and Mr. J. E. Petavel, F.R.S., was also read. The authors found that the temperature gradient varies with the direction and the velocity of the wind, and also with the amount of clouds, being greatest for a north-west wind, and on clear and fine days. It appears that the direction of the wind alters at high levels, rotating in a clockwise direction, thus a south wind tends to become more westerly.

THE INSTITUTION OF CIVIL ENGINEERS.

FOLKESTONE PIER.

At the ordinary meeting on Tuesday, the 12th November, Sir William Matthews, K.C.M.G., president, in the chair, the paper read was "The Extension, Widening, and Strengthening of Folkestone Pier," by Hugh Torrance Ker, M. Inst. C.E. The following is an abstract of the paper:—

This communication describes the important harbour works which were carried out by the South-Eastern Railway Company, at Folkestone, during the eight years 1897 to 1905. The paper begins with a short historical account of the early works carried out for the purpose of providing shelter, and of the continuous fight against the travelling shingle which tended to block the harbour entrance. The accumulation of shingle against these earlier works has resulted in high-water mark being pushed about 900ft. seaward, and the reclamation of about 26 acres from the sea.

The old pier, in 1897, was in a very dilapidated condition, and ill adapted for the rapidly increasing traffic. The number of passengers by the Folkestone-Boulogne route in the year 1905 was 257,000, and the value of goods dealt with was £12,500,000. The new works designed to meet the increased traffic requirements comprise:—The extension of the old pier by 900ft. of solid work, with the provision of four new berths available at all tides and in all weather; the protection of the west face of the old pier by a solid wall carried down to a secure foundation; the strengthening of the root of the pier by a wall founded on cylinders and protected by a wave-breaker of 20-ton blocks deposited pell-mell; the renewal of the east face of the old pier in greenheart piling, and the provision of a new deck throughout its length. The pier is provided with a sheltering parapet along the whole of the western side. The parapet covers the railway platforms, and provides a public promenade on the top. The main lines and sidings on the pier are controlled by electric signalling, and the whole of the pier, landings, station buildings, &c., are lighted by electricity. The pier terminates in a roundhead 65ft. in diameter, upon which stands a granite lighthouse, exhibiting a fourth-order double-flashing light, and a foghorn house with air compressing machinery.

The paper proceeds to describe the construction of the new works, and gives details of the extension, which was composed of 20-ton concrete blocks, of which 133,500 cubic yards were used in the works.

Reference is made to the methods adopted for testing cement, and particulars are given of the boiling test used as a measure of the aeration necessary. Experiments were made with 100-ton lots to ascertain the increase of volume due to aeration, and particulars are given of one of the consignments tested in this manner which continued to increase at a rate sufficient to pay the cost of turning the cement up to the twenty-second turn. Tests extending to three years were also made of cement which had been adulterated with gypsum to control its setting properties, and the results are given, showing a serious diminution of strength in the last year of the test with neat cement, but a steady increase with the mortar test.

After a description of the block-making and stacking, mention is made of the staging from which the actual building was carried on. This staging was 101ft. wide and 400ft. long, with its rail-level 21ft. above high water. It was formed of Oregon pine piles 18in. by 18in., carrying lattice girders of 40ft span. The staging carried two 30-ton and two 20-ton goliath cranes. The 30-ton goliaths were used for handling the diving-bells, of which there were two, each 13ft. by 10ft. by 6ft., weighing 26 tons. The 20-ton goliaths were used mainly for block-setting. The blocks below low water were set block to block, without beds, by the divers. Above low water the blocks were set in beds of 2 to 1 mortar, and the joints were grouted. At the outer end of the pier the foundation was 63ft. below high water. The whole of the west side of the pier is protected against undermining by a concrete apron 13ft. wide. Above low water the pier is faced with granite which was built into the blocks in the yard. Grooves are formed in the granite where the landings occur, to receive the greenheart piles which carry the decks of the landings. Each berth is provided with a lower landing, 20ft. wide, so that passengers may embark with convenience at any state of the tide. Slipways are also provided for the shipment of horses, of which traffic there is a considerable amount passing through Folkestone.

The paper next describes the strengthening works at the root of the pier, where, owing to the proximity of the old work and the amount of cover to be removed before obtaining a good foundation, it was necessary to resort to cylinders to obtain a secure footing in the lower greensand beds. The site of the cylinder foundation was in a re-entering angle exposed to a heavy wave-stroke. The cylinders, which were 11ft. in diameter, were in two rows. Those in the front row were built up of steel rings, 5ft. deep, while in the back row the cylinders were made of concrete, in sections, each weighing nearly 20 tons. The steel cylinders were sunk by means of compressed air, and the concrete cylinders by grabbing in the usual way. The obstructions met with during the process of sinking consisted of the *débris* of the old pier, in the shape of rocks, concrete, and old rails, which had to be cut through. The blockwork wall built on the top of the cylinders was backed with chalk filling, upon which the main pier station was built. The cylinder wall was protected from the abnormal wave-stroke at this point by a wave-breaker, composed of 460 blocks, each weighing 20 tons, placed as irregularly as possible.

The main passenger lines running on to the pier had been liable to damage during stormy weather owing to the loss of shingle which occurred during gales. Foreshore protection works of a permanent character were therefore constructed, consisting of groynes, breast walls, and rockwork barriers.

The paper concludes with a description of the greenheart face and new landings provided on the east face, and with a notice of the special cranes provided for the rapid handling of baggage.

The works were designed by Messrs. Coode, Son and Matthews, and were carried out by Mr. William Rigby, as contractor. The author acted as resident engineer during the construction.

SOME COMPARISONS BETWEEN FRENCH AND ENGLISH ARTILLERY.*

(*Concluded from page 526.*)

TURRETS.

In the British Navy the heavy guns are mounted in barbettes, whereas the closed turret system is adopted by the French. The French turrets are designed with the idea of affording the narrowest possible target, and this idea is carried out even at some expense of roominess inside. They are oval in shape, and the fixed part below the turntable is contracted for the reason above stated. The smaller the turret, of course the less is the total weight of armour necessary, but limited dimensions make it very difficult for the artillerist to arrange conveniently inside all the machinery required for satisfactory working, and on the whole I think the English practice, due principally to that most able and eminent naval architect, Sir William White, of allowing the designer plenty of weight and room inside is the best. The guns and mountings of English turrets of recent type are protected by flat plates, which avoids the necessity for bending the heavy armour. The elliptical form and the proportions of the French closed turrets have the advantage of distributing the blows of projectiles over a greater weight of armour.

It is the practice of both nations to allow the guns to recoil axially, and to take up the recoil by hydraulic buffers. The English run out the guns after recoil by hydraulic pressure, while the French make use of springs which are compressed by the energy of recoil. The training and elevating mechanism are both hydraulically worked in the British Navy, whereas electricity is employed in the French. The same difference occurs with regard to the operation of ammunition hoists and many other details.

Both systems work perfectly well, and have their respective advantages and defects. The great enemy of hydraulic mechanism is frost, and, moreover, the weight of the appliances and the size of the pumping machinery are serious considerations. Electricity, on the other hand, is always and every day available on a battleship. The leads can be taken anywhere, and the apparatus is now thoroughly reliable, although short-circuiting and breakage of leads, should they occur, are much more difficult to find out than the fracture of water pipes.

Hydraulic mechanism, moreover, has approached more closely to the limit of its development than electricity, and, in the future at any rate, I expect electrical power will be generally considered to possess the balance of advantages.

The typical English practice as regards ammunition hoists is to make them in two sections, the lower to bring the ammunition from the magazine to a relay chamber, where it is taken upward again to the gun by another hoist. This system allows of more rapid firing, as there is a large supply of ammunition under the gun; besides, in case of a shell bursting in the turret, the danger to the magazine is not so great. Hence it appears better than the use of a single hoist direct from the magazine to the gun, as is the custom in French battleships. There is another point in which I think the English practice is preferable, that is the possibility of loading the gun at any elevation. The ammunition is carried up in a curved hoist from which it can be delivered at any point and pushed home by a hydraulic rammer moving with the gun. French guns can only be loaded in one position, namely, when the gun is depressed five degrees below the horizontal, so that it has to be brought to this position after every round. The projectile is pushed home without rammer by the men serving the gun, their strength being assisted by a compressed spring, and, of course, favoured by the depression of the gun.

Again, as to sighting, I think the English practice of providing duplicate sights, one set at each side of every gun, is the best.

In both systems there is a most important feature; the whole of the mechanism is arranged to be actuated by hand power if need be, so that should any part get out of order, or the electric or hydraulic power not be available, the guns are not disabled, as they can be immediately worked by the men, who are trained on purpose.

I have compared the turrets on ships now afloat, but I must add that the French naval authorities have acknowledged the advantages of the English practice, which I have pointed out. The turrets for the ships now building will embody all the improvements I have noticed above, such as relay chambers, loading in any position and duplicate sights, so that the rate of fire may be raised to two rounds a minute. Electricity is still retained for motive power.

NAVAL CARRIAGES.

I shall not say much on the naval mountings worked by hand, as they are pretty much alike in both countries; they differ chiefly in the sighting apparatus necessary to obtain hits at all ranges and get the full benefit of the accuracy of the gun. The patterns now in use or on trial are so numerous that it would take a whole evening to examine them and point out their relative merits.

AMMUNITION.

Projectiles.—The projectiles—common shells, shrapnel armour piercing shells, high explosive shells, case shots, &c.—fired in the English and French guns are practically the same, so that there is no difference to point out under this heading. The copper driving bands now universally used on shells of all types are due to that most clever inventor, Mr. Vavasseur, of Elswick.

Powder.—To M. Vieille, a French Government engineer, belongs the credit of having first succeeded, in the year 1885, in transforming gun-cotton into a reliable smokeless powder for military purposes. The Vieille powder is simply a mixture of soluble and insoluble nitro-cotton, somewhat hardened by digestion with ether and alcohol. It is known as "poudre B."

The English service powder as been adopted after a long series of experiments made by the Explosives Committee, of which Sir Frederick Abel was president. This explosive consists of 58 per cent. of nitro-glycerine, 37 per cent. of insoluble gun-cotton (trinitrocellulose) and 5 per cent. of vaseline. The ingredients are incorporated and gelatinised with acetone as a solvent, and the mixture is squirted through dies. It is known by the name of "cordite," owing to the cord-like form it assumes after manufacture. The cords are cut to length and the acetone evaporated. The corresponding French powder, which contains no nitro-glycerine, is rolled into strips.

The cellulose of the gun-cotton being an organic substance must, sooner or later, become altered or decomposed, so that the most important property of these smokeless powders must be their stability, both chemical and ballistic, under all conditions of climate, storage and use, and this for the greatest length of time. The English and French Governments keeping secret all the data referring to that most vital question, I regret to be unable to give any opinion on this particular point.

Cordite, as compared with the "poudre B," gives more regular and, weight for weight, superior ballistic results, and has also a form more convenient to make up into cartridges; but on the other hand, the nitro-glycerine contained in cordite freezes at a fairly high temperature (about 40 degrees F.), and, if frozen cordite is suddenly thawed, a slight amount of exudation of nitro-glycerine is noticed on the surface of the cords. Before re-absorption there is always a risk of explosion from shock or heat. But the greatest drawback of any nitro-glycerine powder is the serious erosion of the bores of guns it causes, even after a very few rounds. For instance, in a 15 cm. quick-firing gun after firing three rounds of Italian ballistite (which contains 50 per cent. of nitro glycerine) the bore of the gun was eroded as much as 0·1in. in diameter for a length of some inches.

As a proof of the slightness of the erosion caused by the French powder, I may say that I have known of a 75 mm. quick-firing field gun that has fired 4000 rounds, and which is nearly as good as new, its accuracy being hardly impaired. Another 10 cm. quick-firing gun on board a French training ship has fired 8500 rounds, the greatest number with practice charges, before being withdrawn from service. I think, therefore, that the English authorities have taken a step in the right direction by having recently adopted a modified form of cordite having only 30 per cent. of nitro-glycerine in its composition.

High explosives.—The high explosive used by both the English and French Governments as a bursting charge for shells is essentially picric acid. In both countries the exact composition used is kept secret, but there seems to be no practical difference between the lyddite of the English Government and the melinite of the French.

Fuses.—Fuses for causing explosion of the charge in a shell are of two kinds; time fuses, which act when the shell has reached a given point of its trajectory, and percussion fuses, which explode the shell when it strikes any object. The fuses used by the English are very different from those used by the French, but as the proper working of a fuse almost entirely depends on the extreme care taken in the minutiæ of manufacture, priming, &c., the differences of design are not of so much importance.

Detonators.—The English provision for detonating lyddite shells consists in having a long tube of asbestos paper fixed axially in the interior of the lyddite charge to contain a bag filled with picric powder (mixture of forty-three parts of ammonium picrate and fifty-seven parts of saltpetre); this is fired by a primer of black powder ignited in its turn by the detonation of a very small quantity of fulminate, when the shell strikes. The detonator for French shells is formed with a strong tube projecting into the melinite and containing a certain amount of fulminate. If the picric powder is stable, and if there is no difference in the efficiency of the two methods, the English would appear safer, as fulminate is a very objectionable material to have except in minute quantities.

Tubes.—For igniting the charges in the chambers of guns, the English use by preference vent-sealing tubes, which are fired by sending a current through a platinum silver wire bridge embedded in a priming composition of gun-cotton dust and meal powder. Provided that the dry gun-cotton dust is not liable to explode spontaneously, the electric tubes seem in all respects preferable to percussion tubes, which contain caps of fulminate, as they are safer, and ignite the charge more instantaneously.

Quick-firing ammunition.—In quick-firing ammunition the projectile powder charge and exploding device are all contained in a brass cartridge case. The advantages are obvious: the powder is well protected, obturators are unnecessary, and rapidity of fire is enormously increased; besides the case prevents serious accidents from back flash, which sometimes occurs when the breach is opened. Quick-firing ammunition is used by both the English and French Governments for guns up to about 6in. bore. When adopting the 6in. Vickers B.L. gun, which does not use fixed ammunition, the Ordnance Committee stated that the chief advantages attained by the use of a silk cloth cartridge were saving weight and magazine space, lighter charges to handle, and economy. It is possible, however, to purchase these advantages too dearly.

GARRISON GUNS.

There is a marked difference in the practice of the English and French as regards garrison guns for coast defence. The mountings of these guns are made by the English of an extremely elaborate character, with the latest improvements; they have, in fact, all the refinements and complications of naval weapons, as well as others, such as disappearing carriages, peculiar to themselves. The French, on the other hand, go in for the greatest possible simplicity, believing that money is more advantageously spent in providing a great number of simple weapons worked by hand power only than in purchasing fewer of a more costly type. Further, the maintenance in good working order of the English garrison guns and mountings is much more expensive, and requires a greater amount of skill than that of the French. However, a new 24-centimetre breech-loading gun has been adopted lately in France for coast defence. It is able to fire four rounds per minute, owing to the use of an automatic loading apparatus.

FIELD GUNS.

The development of the modern field gun has been due to the necessity for providing a weapon to meet the conditions of present-day warfare. The equipment of armies with small-bore rifles, capable of rapid and accurate fire at long range and the invention of smokeless powder, completely altered the tactics adopted in the field. Instead of the serried ranks of soldiers and the slow evolutions characteristic of battles at the beginning of the last century, open order was substituted, and infantry advances were made by short rushes. Under these conditions the enemy's infantry, lying on the ground for the greater part of the time and protected by every bit of cover available, only became a mark for the artillery during the short time, when erect and unconcealed they rushed forward. Against such tactics the older types of field guns were almost powerless.

The position of the enemy's firing line being only roughly known, and its mobility being very great, it became necessary in order to destroy it, or at least to paralyse its offensive power, to sweep with grape shot the whole of the zone occupied. This work, to be effective, must be carried out regularly and systematically, the shells being so placed that every yard of the ground is in turn subjected to the hail of lead. Shrapnel bursting with time-fuses, giving a long ellipse of destruction, is the type of projectile best suited for shelling the enemy's position in this manner.

Besides being capable of performing the function just indicated, modern field artillery must be equally effective with percussion shell against fixed targets, such as the guns of the enemy, buildings, walls, &c. Hence we see that the essentials of a satisfactory field gun are great rapidity of fire, and calibre large enough to take shrapnel of sufficient size and power to destroy men and horses at very long range. It must also be capable of holding its own in an open artillery duel with the enemy's guns, the advantage under such circumstances being possessed by the weapon giving the flattest trajectory and the smallest angle of impact. Furthermore, the sighting mechanism must be as perfect as possible, and special means should be provided to control the systematic sweeping fire of which I have spoken above. This class of firing involves step by step alterations of range and direction, which must be made rapidly and correctly if the full effect of the deadly possibilities of the system are to be obtained.

Before entering into a discussion of the points of difference between French and English practice as regards field guns, I ought to direct your attention to the factors which explain many of the features peculiar to each nation. England is, on account of her geographical position, essentially a naval power, and has directed her greatest efforts to the improvement of armament for fighting at sea. Hence naval requirements have had a profound influence on the design of all war material, and naval ideas have dominated many of the weapons intended for land service. In France, on the other hand, with long frontiers to be protected, national activity has been directed more particularly to the development of material for the army. More attention has been paid to military requirements than in England, and French artillery, both as to material and tactics, is the outcome of the necessity of meeting conditions which England has not to consider so seriously. The army is to France what the navy is to England, and naturally each Power has reached the highest perfection in the sphere in which its interests are most closely involved.

The French artillery experts, after exhaustive trials of various types of field guns, at length decided to adopt that devised by Lieut.-Col. Deport as meeting most fully the requirements of modern field service.

The French field gun is of 75 mm. (2·95in.) calibre, and is built up of a steel tube, strengthened by a jacket and hoops shrunk over it. It is, of course, of the quick-firing type, and throws a 16lb. projectile with a muzzle velocity of 1740ft. per second. The breech mechanism is of the excentric screw type. The carriage on which the gun is mounted is of pressed steel, anchored to the ground by a spade fixed at the end of the trail, the spade being so designed that the re-action of the gun compresses the earth beneath it without ploughing up the ground, or causing the spade to become buried. To prevent the carriage jumping at every round, and to ensure the greatest possible steadiness, the gun is allowed a long axial recoil, being guided meanwhile by three pairs of rollers running in the grooves of a cradle which carries the trunnions. A hydraulic buffer introduced between the gun and cradle regulates the force of the recoil, and prevents any movement of the carriage. A pneumatic recuperator runs out the gun automatically after every round, and the gun thus returns to exactly the original position as regards direction. Firing to the right or left is accomplished by traversing the gun and trail together along the axle, these parts rotating about the spade as a pivot. In traversing they remain always at right angles to the axle, constraining the latter to rotate slightly in order that this relationship is maintained. The required motion is given by means of worm gearing.

On level ground the carriage remains perfectly steady when firing, but to prevent the possibility of lateral movement when the axle is not horizontal, the wheel brakes are arranged so that they may be dropped down and act as scotches to the wheels. To facilitate the working of the gun and to still further increase its stability, the gunners are seated on a saddle on each side of the trail. A steel shield of sufficient strength to protect them from

* Junior Institution of Engineers. Presidential address by M. Gustave Canet.

rifle or shrapnel bullets also aids by its weight in steadying the gun.

The gun has an independent line of sight—that is, it, together with its cradle, is mounted by trunnions on an intermediate framing attached to the carriage. This framing can be rotated about the trunnions. Thus by elevating the framing the gun may be brought to bear point blank on the target, the necessary elevation for range being obtained by separate mechanism, which moves the gun and cradle relatively to the framing. The sights are attached to the framing, and thus remain on the point aimed at whatever alterations or corrections for range may be necessary. The sighting apparatus is placed on the left-hand side of the gun, and consists of a quadrant, on the top of which is placed the pedestal sight. This contains a collimator, in which appear the images of two white lines crossing one another at right angles. Sighting is effected by moving the gun until the intersection of the lines coincides with the object sighted. This, in general, will be chosen for convenience by the battery commander, and will not be the same object as that aimed at, the latter being usually out of sight of the gunner. A goniometer dial, graduated in thousandths, is set at some angle to the right or left of zero, prescribed by the battery commander, so that when the sights are on the object given the gun will be pointing in the direction required. Should the shield interfere with the use of the pedestal sight the latter can be raised on a long bar until clear of obstruction.

The service of the gun requires three men, whose duties are as follows:—The layer, who is seated on the left-hand side, sets the pointer on the graduated quadrant to the angle of sight, and lays the gun. There is on the quadrant a spirit level which is put horizontal when the angle of sight is correct, and the layer keeps it always so during firing. The elevating number, seated on the other side, gives elevation for range as instructed by the battery commander. These two operations are quite independent, and can be accomplished simultaneously. The third man is the loader.

With the sighting attachment described, the French field gun fulfils the conditions I have mentioned above. It is used behind cover whenever possible, and entirely concealed from the enemy; and with it an area of ground can be swept with shell in width and length with ease and accuracy. The work, moreover, is done with great rapidity, twenty rounds a minute being fired, and every shell placed so accurately that the whole of the ground is covered with the minimum amount of ammunition. To attain this speed of firing the ammunition wagon is brought alongside the gun, and tilted backwards round its axle, so that the cartridges lie nearly horizontally, and each may be taken from its pigeon-hole more easily than a book from a bookcase. The sides of the wagon and the doors are of thin armour plate, the latter, when open, forming wings to protect the men serving the gun. Further, delay and errors in setting the time fuses by hand are avoided, as this is done instantaneously by means of a special fuse-punching machine. This device is furnished with a corrector for taking account of the atmosphere and other conditions which may prevail at the time. The French attach great importance to the rapid opening of fire, and provide instruments to facilitate this and to correct any initial errors immediately the effect of the first shots is noted.

Time will not permit me to enter into greater detail, but what I have said is sufficient to show that the French, in introducing the modern field gun, made radical departures from the previous practice of any country. When the gun was issued to the troops it was subjected to severe criticism by experts on the ground that it was too delicate and complicated for field service, and that it would entail a great waste of ammunition. However, its qualities are now generally recognised, and every country has since built weapons on similar lines.

The field gun of the English army is of the wire-wound construction, with an inner tube of nickel steel. It is of 3·3in. calibre, and throws an 18¾ lb. shell with an initial velocity of 1610ft per second. The breech action is of single motion screw type, with a repeating trip lock. The gun is guided by two longitudinal guide ribs, and recoils on a bronze cradle, the trunnions of which are inclined to the horizontal in order to compensate for the mean angle of drift. The trail is formed of a cylindrical steel tube and terminates in a spade, the latter being without the horizontal flange, which is adopted, and I think rightly, by the French. A hydraulic buffer lying above the gun checks the recoil, and surrounding the buffer are telescopic springs for running out the gun automatically after firing. The lowness of the gun obtained by this arrangement is favourable to its stability, but the buffer springs are rather exposed to the enemy's fire. Moreover, lowness must not be carried too far, because of the danger of injury to the chase when crossing ditches and rocky ground. The French gun, it will be remembered, is mounted above the recoil and running-out mechanism, but the extra height is neutralised to a slight extent by making the wheels some 4in. less in diameter than is the English standard practice. As to the relative advantages of springs and compressed air for running out, I am inclined to prefer the latter. Springs are heavy, and if they fail, are difficult to obtain in time of war. Air, on the contrary, costs nothing, and by pumping a little more into the cylinder the running up force may be accurately adjusted to the highest angles of fire, or increased to compensate for any extra friction of the gun in its slides.

The English gun, with its cradle, is mounted on a sort of turntable on the axle, on which it is traversed for direction. The traversing mechanism is thus very simple and light to handle, but at the limit of traverse there is an angle between the direction of recoil and the plane of the wheels, which involves a tendency to shift the gun sideways. Scotching is dispensed with by the English authorities, and I think they are justified in considering the operation unnecessary. Independent sighting is adopted on the English field gun, the left-hand trunnion of the cradle carrying a telescope and open sight, pivoted so that it can be traversed horizontally. The elevating mechanism is on the right-hand side, and the angle of elevation above the horizontal line is recorded on a drum calibrated in yards of range. It seems to me questionable whether telescopic sights are necessary or advisable for field guns, as the conditions are entirely different to those prevailing in naval warfare.

The shield of the English gun consists of two portions, the lower of which is hinged up when the gun is not in use. The upper part is curved backwards, and affords more protection to the men than the French shield. The service of the gun is practically identical in the two armies, except that the English practice is for the layer to do the firing. The ammunition wagon is not made to tip up, but is opened from the rear, the door hanging down to protect the legs of the men. The fixed ammunition is held in cells of basket work, while the French wagons are fitted with metallic bearers for the ammunition, which would seem much more efficient in preventing injury to the thin cartridge cases. The device for setting the time fuses does not appear to permit of setting being done with the same rapidity and certainty as the plan adopted by the French. This is a very important point, as upon it naturally depends very largely the efficiency of the firing.

Of the mountain guns, siege guns, howitzers, and similar weapons, I need not speak, as where French and English practice differ with regard to them, the points of difference will be understood from what I have said respecting field guns.

In drawing this address to a conclusion, I am aware that there are many points of interest which I have not touched upon, and others which deserve more discussion than I have been able to give them. But an attempt to deal at all exhaustively with the subject of guns and ammunition, in one short evening, is out of the question. The field is too broad for more than a hasty survey, and if I have interested you in this most interesting branch of engineering, I shall feel that my object has been realised. I may have seemed critical at times, and have not hesitated to express my opinion on some very controversial matters, but I have endeavoured to be just to both sides.

My interest in guns is now purely a scientific one, and my sympathies are with what seems to me to be the best engineering—whether found on this side of the Channel or the other. There are often, however, many different ways of obtaining a result, and all equally good, though custom and long familiarity with one may make it appear preferable to any other. I am no longer young enough to think that those who differ from me on any point are necessarily wrong, and I trust that I have said nothing this evening which could possibly be taken as a disparagement of other men's work, or a reflection upon the services of either country. In fact, I would rather record my admiration for the unremitting attention which the engineers and technical officers of both England and France give to the improvement of armament for the defence of their respective territories. Their responsibility is exceedingly great, and although they may differ in opinion as to details, we may be confident that they each and all agree in striving for the honour of the services in which they are interested. May it be long before the war equipment of either of our great nations is put to the supreme test, and may the day never dawn when there is a thought of comparing them in a less friendly manner than I have done to-night.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made at the Admiralty:—

Engineer Captains.—W. Sharp, to the Niobe; G. Elbrow, to the Prince George; J. J. Stuart, to the Euryalus, all additional, for service on staff of Rear-Admiral; C. J. North and R. B. Priston have been promoted to the rank of Engineer Rear-Admiral, with seniority.

Engineer Commanders.—H. C. McLean, to the Pembroke, additional, for the Diadem; C. T. D. Greetham, to the Astræa; G. E. Wheatley, to the Espiegle, additional, for Dartmouth College; H. Basson, to the Goliath; J. T. Parkis, to the Hawke, on recommissioning; R. Spence, to the Mercury, additional, for submarines, and to assist on the staff of Admiral-Superintendent at Birkenhead; H. S. Rashbrook, to the King Alfred, additional, and on recommissioning; P. D Martell, to the Victory, additional, for oil fuel course; F. G. Dawson, to the Vivid, additional, for the Theseus; W. C. Burnett, to the Duncan; H. J. Leader, to the Barfleur, additional, for the Centurion; C. E. Eldred, to the Victory, additional, for four months' study in Italy; A. P. L. Dupen, to the Victory, additional, for the Boadicea, and for service on the staff of the Admiral-Superintendent of the district; C. E. H. Osbourne, to the Sappho, on recommissioning; R. W. Perry, to the Encounter, additional, and on recommissioning. The undermentioned Engineer Commanders have been promoted to the rank of Engineer Captain:—J. J. Frost, with seniority; J. W. Hole, with seniority; and G. G. Goodwin, with seniority, and appointed Deputy Engineer-in-Chief.

Engineer Lieutenants.—T. G. Coomber, to the Devonshire, temporary, on recommissioning; C. M. Weeks, to the Lancaster; P. H. Meynell, to the Victory, additional, for the Superb, for service on the staff of the Admiral-Superintendent of the district; P. C. Minhinnick, to the Hindustan; J. B. Nicholson, to the Leander, additional, for the Greyhound; E. V. Waud, to the Sappho, on recommissioning; L. H. Black, to the Essex; C. J. Hawkes, to the President, additional, temporary, for service in Dockyard Branch, Admiralty; F. E. Lamb, to the Victory, additional, for the Star; W. N. McDonald, to the Tamar, additional, for duty at Hongkong yard under chief gunner; C. J. Hammond, to the Jason; A. D. Worth, to the Flora; J. F. Bell, to the Widgeon; E. Nibbs, to the Bonaventure; H. Goold, to the Surprise; A. E. Everitt, to the Tamar, for the Otter; J. Kelly, to the Tamar, for the Fame; W. C. G. R. J. Grant, to the Excellent, additional, for the Revenge; W. J. Deans, to the Cambrian; A. C. Turnbull, to the Excellent, additional, for the Grafton; W. J. Duffell, to the Psyche; T W. Cleave, to the Blake, additional, for the Eden; H. D. Robinson, to the Crescent; F. S. Ainsworth, to the Pembroke, additional, for the Diadem; T. H. Greenwood, to the Vivid, additional, for the Theseus; A. Turner, to the President, additional, for service in Controllers' Department; J. N. Tucker, to the King Alfred, on recommissioning; J. C. Matters, to the King Alfred, additional, and on recommissioning; G. J. Sisley, to the Hannibal; E. R. Amor, to the Hawke, on recommissioning; W. E Townsend, to the Sappho, on recommissioning; H. H. Willmore, to the Blake, additional, for the Rother; W. H. Outfin, to the Vivid, additional, for the Theseus; D. D. Cunninghame, to the Donegal. Engineer-Sub-Lieut. H. G. Moon has been promoted to the rank of Engineer-Lieutenant, with seniority.

Engineer-Sub-Lieutenants.—H. Bleackley, to the Carnarvon; J. D. Sturrock, to the Leviathan; R. H. G. Boddy, to the Sappho, on recommissioning; H. B. McGhie, to the Encounter, additional, and on recommissioning; Mcl. G. A. Edwards, to the King Alfred, on recommissioning; M. Martin, to the King Alfred, additional, on recommissioning; P. King, to the King Alfred, additional, on recommissioning; H. B. McGhie, to the Vivid, additional, for the Theseus. The undermentioned engineer sub-lieutenants have been promoted to the rank of engineer-lieutenant, with seniority as follows:—G. H. Turrall, with seniority; G. Robins, with seniority; S. C. Church, S. G. Wheeler, W. Waters, G. E. W. McEwen, C. W. Keats, and R. H. Withey, with seniority. The appointment of Sub-Lieut. H. H. G. Begbie to the Highflyer has been cancelled.

LONDON SMOKE.—A conference on "London Smoke: its Effect on Health," was held at the Institute of Hygiene, 18th inst. Sir William Richmond, who presided, said that experience went to show that smoke was bad for the nervous system, bad for the bronchial tubes, bad for the eyes and bad for the nose, but as he was not a doctor he preferred to speak of it so far as it affected himself, and its influence on works of art and decoration generally. The action of sulphuric acid present in smoke has an influence upon even marble, and will destroy copper wire. The frescoes in the Houses of Parliament were destroyed, and much other damage would be chronicled through this cause. He quoted the late Sir William Broadbent as being a strong believer that smoke had a very bad effect on health, and he referred to the action successfully taken to save the plants at Kew Gardens which, many of them delicate, suffer from smoke like human beings. Dr. des Voeux said he would move the following resolution:—"That the coal smoke in the atmosphere is injurious to health and lowering to vitality, and that every possible means should be adopted to find a remedy." He described the chemical constituents of smoke and asked what are the deleterious constituents. He said that he believed these were the sulphurous compounds. The carbon was carried into the lungs, but he did not think this did any harm—the sulphurous compounds were, however, very irritating. Dr. Ascher, a German doctor, had made a very close study of this subject and he found that disease and mortality were greater nearer to factories and where there was much smoke, and he proved beyond a doubt that human vitality was much less when living under the influence of smoke. Smoke produced many troubles, including indigestion and catarrh of the stomach, and its worst effect was when smoke was in combination with fog. He thought the indirect effect on health was, however, even greater than its direct effects, and while he was anxious not to overstate the case, he certainly thought it seriously impaired health. Mr. Chubb dealt also with the chemical effects, and suggested the burning of smokeless fuel. Mr. Baines said the difficulty was to find a practical remedy, and he hoped this would be proposed at the meeting. Other speakers having stated their views, the resolution was put to the meeting and carried unanimously.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Winter and Coal Trade.

THE coal trade is the business which this week shows up most favourably. The first appearance of frost and snow is heartily welcomed by the coalmasters, who were becoming depressed concerning the adverse state of the trade. Winter surroundings have come just in time to save the price situation. This was being undermined by a fall in best deep house coal for the London market of 2s. to 2s. 6d. per ton. A rebound in favour of the colliery owners is now certain. Ironmasters give little hope that the improvement in the coal trade will communicate itself to them.

Bar Iron Values Falling.

Though there is a fair current of business still being done in marked bars at the £9 basis under old contracts, the Staffordshire bar trade generally has been unfavourably influenced by the 10s. fall announced in Lancashire and Yorkshire bars and by the 12s. 6d. drop in best bars reported from Scotland. The North Staffordshire makers, led by Messrs. Robert Heath and Sons, have reduced their standard from £8 to £7 10s. They state that they have experienced no relapse as far as demand is concerned, but that their hands have been forced by the prior reductions in prices in the competing districts. The North Staffordshire reduction reacts detrimentally on South Staffordshire bars. Unmarked bars, which have hardly maintained their position during the past week or two, are perceptibly easier. Though the quotation for common bars remains nominally at £7 5s. and £7 2s. 6d., a large portion of the iron sold changes hands at lower rates. Considerable uneasiness is felt at the growing encroachments of Belgian competition. It is now stated that supplies can be had from Belgium at £6 5s., delivered in this district, but allowance must be made for the low grade of the iron. At the figure mentioned business amounting to something like 30,000 tons has, it is rumoured on the Birmingham Exchange, recently gone to Belgium in one line. Previously the buyers purchased in Lancashire and Staffordshire, but they would get a better quality of iron here than from the Charleroi works.

Staffordshire Marked Bar Prospects.

There is no corresponding announcement at present concerning Staffordshire marked bars to that made in North Staffordshire. But most probably the effect of the North Staffordshire announcement has yet to be felt by the makers in this district. Marked bars of South Staffordshire brand remain for the present at £9; second grade, £8; merchant bars, £7 5s. to £7 7s. 6d.; and common bars, £7 to £7 2s. 6d. The opinion, however, is strengthening that we shall soon see a reduction of 10s. in the marked bar standard, bringing it down to £8 10s. per ton.

Black and White Sheets.

Sheets are weaker both in demand and price, and some of the mills are now running short time. These matters have to contend against both foreign and British competition. Doubles are £8 5s. to £8 7s. 6d. this week ready for immediate delivery, and for forward business considerably less will be taken; lattens are £8 17s. 6d. to £9 now. White corrugated sheets are still £13 2s. 6d. for 24 W.G. material delivered Liverpool or equal. The export business with South and Central America is said to have been disorganised to a great degree by the disturbance in the rate of "exchange."

Raw Iron Market.

Forge pig iron makers report continued pressure for deliveries, and some sellers are inclined not to discuss consumers' offers of small prompt orders, which alone are offering; but on the whole it would not be accurate to estimate the state of the market from these circumstances. The crucial test is in the fact that contracts are being worked off much faster than new ones are coming forward, and some of the best makers report that so far their order lists for next year are light. The foundry trade, which has maintained its firmness better than any other branch, now finds itself with diminishing orders. Up to the present, however, there has been no serious giving way in the prices of foundry pigs as far as recognised standards are concerned. Forge iron is quoted this week:—Staffordshire, common, 56s.; part-mine, 58s. to 59s.; best all-mine, 87s. 6d. to 92s. 6d.; cold blast, 115s.; Northamptonshire, 56s. to 57s.; Derbyshire, 57s. 6d. to 58s. 6d.; North Staffordshire, 58s. 6d. to 59s. 6d. per ton.

German and Belgian Steel Competition.

This—Thursday—afternoon on Birmingham Exchange the steel trade was apparently suffering from increasing continental competition, and also from abundant "cutting" from other English districts. Belgian billets and tin bars are said to be offering as low as £4 15s. to £4 18s. 9d. In face of such figures it is exceedingly difficult for native makers to seek to maintain English quotations at £5 5s. or £5s. 7s. 6d. Buyers will not give the price for any but prompt lots. Belgian finished steel bars are quoted in some transactions as low as £6 to £6 5s., against £7 to £7 5s., and occasionally £7 10s., quoted for native material. The position of steel-masters was rendered worse to-day by the circumstance—given with the appearance of a good deal of authority—that the Stahlwerks-Verband have, within the last few days, formally entered the British market against our own makers for the trade in raw steel. A report was current to-day that one of the largest English or Welsh consumers of steel bars or billets for rolling down into sheets has just placed a contract for 25,000 tons of bars direct with the Verband for English delivery between the beginning of January and the end of March next year.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Wednesday.

A Month's Retrospect.

THE month of November has had no redeeming feature so far as pig iron is concerned. The turnover has been on a small scale comparatively, and makers even have had to quote lower prices for prompt delivery. This has been most marked in Lincolnshire, which is about 6s. 6d. per ton lower than at the end of September. In the early part of the month the price went down 2s. 6d. per ton, but, contrary to general expectation, there was no alteration at the meeting of the Pig Iron Association held a week ago. The course of the warrant market has been variable during the month. Opening anything around 54s., they dropped to a shade under 50s., but it is noteworthy that Middlesbrough brands did not follow the same course, and there was a firmer feeling here at the close. These have, however, to some extent followed the course of warrants, closing about 6d. lower. Still shipments of Cleveland continue heavy. Staffordshire and Derbyshire have followed suit in some respects to the extent of 1s. to 1s. 6d. per ton, with a slow demand for prompt delivery. Hematite has fallen, West Coast being quoted 71s. 3d. at the opening f.o.t., and closing 69s.; and East Coast, 72s. 6d., closing at 70s. f.o.t. The course of Scotch has not been quite so marked. Glengarnock has been unobtainable in first hands, and closes nominal, but Gartsherrie is nearly 2s. per ton lower, and other brands used locally also show an almost corresponding reduction. There is, however, a better feeling at the close. Forge iron to some extent shared the dulness in foundry, and prices are generally lower.

Finished Iron.

Notwithstanding the reduction already noted merchants report a slow business, orders being by no means plentiful.

Steel.

There is little new to report. It is stated that strong efforts are being put forth to obtain orders, and that one line of many thousands of tons has been secured by Germany. Notwithstanding this, English makers are well employed on constructional work.

Copper.

There is some improvement to note. Both sheets and ingots are dearer, while brass tubes are also fractionally higher.

Quotations.

Pig iron: Lincolnshire No. 3 foundry, official, 58s.; Staffordshire, 58s. 6d.; Derbyshire, 59s. 6d.; Middlesbrough, open brands, 58s. 7d. Scotch: Gartsherrie, 68s. 9d.; Glengarnock, nominal; Eglinton, 65s. 6d. to 66s.; Dalmellington, 65s., delivered Manchester. West Coast hematite, 69s.; East Coast ditto, 70s., both f.o.t. Scotch, delivered Heysham: Gartsherrie, 66s. 6d.; Eglinton, 66s. 3d. to 63s 9d.; Dalmellington, 62s. 9d. Delivered Preston: Gartsherrie, 67s. 9d; Eglinton, 64s. 6d. to 65s.; Dalmellington, 64s. Finished iron: Bars, £7 10s.; hoops, £8 2s. 6d.; sheets, £8 5s. Steel: Bars, £7 5s. to £7 15s.; hoops, £8 2s. 6d.; sheets, £8 15s.; boiler plates, £8 12s. 6d.; plates for tank, girder and bridge work, £7; English billets, £5 5s. to £5 10s.; foreign ditto, £4 17s. 6d. to £5. Copper: Sheets, £80; tough ingot, £68; best selected, £67 per ton; copper tubes, 10d.; brass tubes, 8d.; condenser, 9d.; rolled brass, 7¼d.; brass wire, 7¼d.; brass turning rods, 7d.; yellow metal, 7d. per lb. Sheet lead unchanged at £22 5s. per ton. English tin ingots are slightly higher, being £141 per ton.

The Lancashire Coal Trade.

There was a large attendance on the Coal Exchange on Tuesday, many merchants being attracted by the meeting summoned under the auspices of the Manchester and Northern Counties Coal Traders' Association with regard to railway rates. The grievances of traders have at last been recognised by the Board of Trade, and the matter will, in the course of a couple of months or so, again come up for a definite understanding to be arrived at. The meeting was admitted on all hands to have been a very successful one. The tone of trade on the Exchange showed little improvement. Slack, however, had a well-sustained demand, but house coal was quiet, and demand for bunkering coal is falling off. In some instances coal is being offered from outside districts at under official rates, but there has been no change to note in local quotations.

BARROW-IN-FURNESS, Thursday.

Hematites.

There is no improvement to note in the demand for hematite iron, and the volume of business being transacted is small, and scarcely sufficient to employ the reduced number of furnaces now in blast. Some business is now being done in forward deliveries at 67s. 3d., which is a proof that makers and buyers alike are assured of a further reduction in prices before any return to higher values is reached. The large number of orders in hand three months ago have been practically all worked out, and new business is coming to hand in much smaller volume. Yet stocks show a further reduction this week, and now stand at 6482 tons, while makers' stocks are practically non-existent. A smaller trade is being done in special hematite classes, and business in spiegeleisen and ferro-manganese is not so large as it has been. A few sales of scrap iron are noted at fairly good prices. The position of the iron ore trade is very quiet, and less raw material is being sold at cheaper prices, 14s. per ton being the value of good ordinary sorts net at mines. Foreign ores are not being imported so largely as of late, and in West Cumberland large stocks are held.

Steel.

A very quiet time is being experienced in the steel trade. The demand for railway material is quiet, and shipbuilders are not at the moment requiring large deliveries of plates or sections. The rail mills at Barrow have been working single shift this week, and the plate mills have been on full time. A fuller demand for shipbuilding material is expected, and it is hoped lower prices for railway material will encourage the placing of new orders. Merchant steel is in quiet demand.

Shipbuilding and Engineering.

No new orders have been booked for shipbuilding tonnage of late, but the work of making out tenders for some large vessels has been engaging the attention of the draughtsmen and cost clerks for some time past. Engineers are well employed, and it is expected before the present orders have been cleared out new and important business will be secured.

Shipping and Coal.

The exports of iron and steel from West Coast ports last week were 15,375 tons, a decrease of 205 tons on the corresponding week of last year. The aggregate shipments this year to date have reached 775,601 tons, being an increase of 29,891 tons on the corresponding period of last year. Coal and coke are cheaper, but large consumers are trying to get prices still lower than they are.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

House Coal.

A COLD snap, brief though sharp, caused a "spurt" to some extent in the demand for house coal, which had weakened somewhat of late. At the time of writing, however, conditions are again milder. It is evident that a comparatively short spell of winterly weather would soon account for any accumulations which may exist. The business done with London, the Southern and Eastern Counties, and markets generally, is quite an average one. Best Barnsley coal is maintained at 13s. 6d. to 14s. 6d. per ton; secondary qualities, 12s. to 12s. 6d. per ton.

Export Coal Business.

Late as it is in the year, the export trade is still open, but information has been received locally that the season may be expected to close quickly. The shipments are gradually getting less for the higher ports of the Baltic. From Hull, for the week ending November 19th, the weight of coal taken to distant markets was 71,983 tons, against 68,763 tons for the corresponding period of last year. Stettin headed the list with 8334 tons, Hamburg coming second with 8055 tons, and Alexandria next with 6623 tons. From Grimsby, for the week ending November 22nd, the weight of exports was 32,769 tons, against 39,425 tons for the corresponding period of last year. Two Swedish places received the largest weight from Grimsby during the week mentioned—Gefle with 4833 tons, and Ahus with 2975 tons.

Steam Coal for the Home Market.

There is no falling off in the demand for home consumption, a ready market being found for all the output. Such surplus as may be left as the export trade gets smaller will be absorbed in other ways. The different railway companies are receiving full stipulated deliveries under contracts at 12s. per ton. It is expected that certain supplementary railway contracts which expire at the end of the year will be renewed at the same rate. The contracts for the supply of Yorkshire hards for the Humber fishing fleets, which also fall out at the close of December, are usually regulated by the railway contract rates. We cannot hear that negotiations for renewal of arrangements for supplies have reached any definite stage. Steam coal in the open market fetches from 12s. 6d. to 13s. per ton at the pit, with no prospect of lesser quotations ruling later on.

Coke, &c.

The prices of coke are again lower, the quotations now ruling being 13s. 6d. to 14s. 6d. per ton for best washed and 12s. 6d. to 13s. 6d. per ton for unwashed. These figures show a reduction of 1s. a ton since last report. The cause given is on account of small coal not being in such plentiful demand from this district as was the case a few weeks ago. More ovens have therefore been put in operation for the supply of coke, and the supply is temporarily beyond the demand. The bulk of the output is taken by North Lincolnshire, Derbyshire, Leicestershire, and other iron-smelting districts. Slacks, in the best qualities, for steam-producing purposes, still stand at 6s. 6d. to 7s. per ton.

Hematites.

In consequence of the export trade still continuing, the feeling is that prices will stiffen. In our last report the opinion was expressed that the continued depletion of stocks would soon reduce the demand to the supply. That view of affairs there is no reason to modify this week. Quotations are not altered. West Coast, 86s. 6d. to 88s. 6d. per ton; East Coast, 82s. 6d. to 84s. 6d. per ton; East Coast subject to 2½ per cent, and both delivered in Sheffield and Rotherham.

Lincolnshire Irons.

There is no change in the official quotations from those given last week. No. 3 foundry, 56s. per ton; No. 4 foundry, 56s. per ton; No. 4 forge, 56s. per ton; No. 5, mottled, white, and basic, 58s. per ton. At these rates some extra business has been done in various quarters, but it continues to be in moderate weights, and for delivery as early as possible. We do not hear of any eagerness to buy for forward delivery, purchasers appearing satisfied to provide for their immediate requirements.

Derbyshire Irons Lower.

A reduction of 1s. a ton is reported this week in Derbyshire irons, No. 3 foundry being now 59s. per ton, and No. 4 forge 57s. per ton.

Bars Reduced.

The South Yorkshire Bar Iron Association have reduced quotations for bars, which are now at £7 10s. to £8 per ton. Sheets are unaltered at £10 10s. per ton; Bessemer billets, £8 15s. per ton; Siemens billets, £9 5s. per ton. Foreign competition in steel billets is reported to be increasingly keen.

The Heavy Industries, &c.

The department of the heavy industries, which is most satisfactorily engaged, and in which the prospects are most promising, is that of railway manufacture. Rolling stock material in wheels, tires, springs, axles, buffers, and similar productions is being largely turned out, and to the brisk foreign and colonial trade there are now being added increased inquiries on account of home railway companies. The principal distant markets are India, South America, and Australia. There is no improvement to be noted with regard to marine and military material. Fresh orders in both departments would be exceedingly acceptable. In the lighter steel trades the business is looked upon as satisfactory. There have been of late rather fewer inquiries for tools and files, but good work remains on the order books—sufficient, it is stated, to give full employment for months to come. The file trade has been exceptionally brisk during the whole year.

NORTH OF ENGLAND.

(From our own Correspondent.)

Position and Prospects of Trade.

THE slackening of business in the iron and steel industries has gone on at a very rapid rate, and the tone of local trade may now fairly be characterised as depressed. Up to September there appeared little indication that the prosperity which had been enjoyed since the early part of 1904 was so soon to end, and that the transition from good trade to bad would be so quickly effected. There is no doubt that the condition of the money markets at home and abroad has been the main cause of the change, for the dearness of money has checked enterprise on all sides, and confidence has given way, just before the advent of the slackest period of the year. Consumers are not disposed to buy iron and steel for delivery more than a few weeks ahead, as the tendency of prices is so markedly downward that it appears to be the best policy to wait, and then full advantage of the falling quotations can be taken. The unsatisfactory estimate of the outlook is indicated by the fact that the three months' price of Cleveland pig iron warrants varies from 1s. to 2s. per ton below the prompt rate. That trade is declining rather quickly in countries abroad, which during the last three years have taken very considerable quantities of Cleveland iron, &c., because they were unable to satisfy their own requirements, is apparent from the fact that they are making more than enough now to satisfy these requirements, and Germany and Belgium are beginning to "dump" their surplus production on our shores at prices below those which our own manufacturers ask. A considerable tonnage of German plates is reported to have been bought by consumers in this district, and some 25,000 tons of steel billets and blooms are also to be brought from Germany over to this country. That is a not infrequent occurrence when German home demands fall off. It is pretty clear that trade is on the ebb now, and the chances are that it will continue to be so over the winter, and probably further ahead.

Cleveland Iron.

The makers of Cleveland pig iron are still well off for orders; in fact, their production has not yet overtaken the requirements, and every ton that is made by the furnaces goes at once into consumption. Ironmasters are not accumulating any stock, and that more pig iron could be disposed of if it were forthcoming is shown by the fact that the stock in Connal's public stores has been reduced over 20,000 tons this month. The production of pig iron in the North-East of England has this year been by a good deal the largest on record, and yet it has been exceeded by the requirements, seeing that the output has had to be supplemented by 442,000 tons taken out of the public stores. Not since March, 1906, has the production of Cleveland pig iron been equal to the wants of consumers. Makers over the last 18 months have not been able to accumulate any stock at all, but it is now probable that they will find their output exceeding the requirements. It is, however, expected by a good many that the output will be reduced, for opportunity will be taken to re-line some of the furnaces, which badly need it. There is a difficulty in getting an adequate supply of ironstone locally, and if prices decline further the using of Northamptonshire stone cannot be carried on as heretofore. Comparatively few orders for Cleveland pig iron have lately been booked, and consumers buy from hand to mouth. No. 3 Cleveland G.M.B. pig iron, which was at 51s. per ton on Monday for early f.o.b. delivery, was at 50s. 6d. on Wednesday, No. 1 being at 55s. 6d., No. 4 foundry at 50s., and No. 4 forge at 49s. 6d.; but these figures were little better than nominal.

Hematite Iron.

The prospects in the East Coast hematite iron trade are even more unfavourable than are those of the ordinary Cleveland iron business, as the depression in the steel industry becomes more general. Prices are more than consumers can afford to pay; 69s. per ton for mixed numbers is considered too much when no more than 50s. per ton can be secured for No. 3 Cleveland G.M.B. pig iron—in fact, even 50s. would be thought too much. The output of hematite iron has been considerably reduced. Makers are quoting 70s. per ton for mixed numbers, but some will accept 69s. 6d., and second hands quote 69s. The producers' figure is 12s. 6d. per ton below the highest price of the year. Rubio ore is nominally at 17s. 6d. per ton. Consumers are at present well bought, and not inclined to purchase more at present.

Realised Prices of Finished Iron.

The secretaries of the Conciliation and Arbitration Board for the Manufactured Iron Trade of the North of England have this week announced that the accountants to the Board, after the usual examination of the producers' books, have ascertained that the average price realised for the manufactured iron delivered by firms in the North-East of England during September-October was £7 6s. 9·10d. per ton—9·85d. per ton more than in the previous two months—and this does not entitle the men to any advance, so that the wages for December and January will be the same as has ruled during October-November. The puddling rate is now 9s. 3d. per ton, or 1s. 6d. more than since prices began to move up, and other wages have improved 15 per cent. since the minimum was touched in the early part of 1904. The average just reported is the highest that has been announced since January-February, 1901, and it shows an improvement of 11s. 10d. this year, while as compared with the £5 16s. 4d., the lowest of the last decade, there has been a rise of 30s. 4d. per ton. Iron rails in the last two months realised £7 0s. 9d.; iron plates, £6 15s. 8d.; bars, £7 7s. 1d.; and angles, £7 13s. 0½d. per ton. The quantity delivered was about the same as in the previous two months.

Manufactured Iron and Steel.

In nearly all branches buying is very slow, and it is difficult to keep the mills going fully. The department that is the best off at present is that producing galvanised and corrugated sheets, and the works making these will be well off for several months to come even if they get no more orders. The quotation is maintained at £13 2s. 6d., less 4 per cent. Heavy steel rails are at £6 5s. net f.o.b., and there is a slightly better inquiry.

Shipbuilding.

There is not the slightest improvement in the shipbuilding industry, and prospects are unfavourable. More especially is this noticeable in the Sunderland district, where it is estimated that 8000 men are out of work. Two of the shipyards are entirely closed. The employers there have given notice to the boilermakers, shipwrights, joiners, drillers, and painters, that from December 26th wages will be reduced 2s. per week on time work, and 5 per cent. on piecework.

Improvements at the Hartlepools.

The North-Eastern Railway Company has decided to improve the accommodation at the Victoria Dock, Hartlepool, extensively; in fact, it is proposing to spend £125,000 over the undertaking. It is intended to do away with the existing dock entrance, thus making a valuable addition to the present dock facilities by obtaining a tidal harbour, which would be dredged to a considerable depth, and so enable vessels of large size to take advantage of the existing quays, which will have to be strengthened. New staiths will be erected. Provision will be made for a greatly increased fishing trade by erecting a substantial fish quay on the eastern side of the dock.

Coal and Coke.

The demand for both coal and coke has slackened, the export demand especially, and in several branches easier prices have to be reported. Both coking coal and also coke have dropped in value in sympathy with the fall in the quotations for pig iron. Coking coal is freely offered at 12s. per ton, and medium coke at 17s., delivered at the Middlesbrough furnaces. Coke manufacturers are keen sellers. Foundry coke can be got at 20s. per ton f.o.b. Bunker coals have dropped, and small steam is down to 9s. 3d., where lately 10s., and even 10s. 6d., was paid. Gas coals keep up fairly well, the best realising 14s. f.o.b., and seconds 13s. 3d.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Trade Outlook.

A GLANCE round the various staple trades shows hardly any sign of improvement. Most of them are merely kept going on contracts arranged some time ago, or working on orders given from hand to mouth. The impression is strong that values of material and fuel, as well as rates of wages, require to be further reduced before orders are attracted in large quantity, or manufacture conducted on profitable lines.

Pig Iron Warrant Market.

The Glasgow warrant market displayed a considerable amount of strength at the opening this week, the position being regarded as encouraging owing to the continued heavy shipments of iron from the North of England. Business was done in Cleveland warrants at 50s. 3d. to 50s. 6d. cash, and 49s. 5d. to 49s. 11d. one month. Subsequently the market became flat, with transactions at 50s. cash and 49s. 9d. one month. Cumberland hematite has been at 48s. to 47s. 9d., with little or no business doing. The tone of the market has since been irregular.

Output and Prices of Makers' Iron.

There are now 85 furnaces in blast in Scotland, compared with 90 at this time last year, and of the total 41 are making hematite, 38 ordinary and six basic iron. There has been a fair demand for Scotch makers' iron, generally for early delivery, and the prices have been somewhat steadier. G.M.B., No. 1, is quoted at Glasgow, 65s.; No. 3, 61s.; Govan and Monkland, No. 1, 65s. 6d.; Nos. 3, 61s. 6d.; Carnbroe, No. 1, 66s. 6d.; No. 3, 62s. 6d.; Clyde, No. 1, 68s. 6d.; No. 3, 63s. 6d.; Gartsherrie, No. 1, 69s.; No. 3, 64s.; Calder, No. 1, 72s. 6d.; No. 3, 67s. 6d.; Summerlee, No. 1, 73s. 6d.; No. 3, 65s.; Langloan, No. 1, 75s.; No. 3, 70s.; Coltness, No. 1, 90s.; No. 3, 70s.; Glengarnock, at Ardrossan, No. 1, 72s.; No. 3, 66s.; Eglinton, at Ardrossan or Troon, No. 1, 64s.; No. 3, 61s.; Dalmellington, at Ayr, No. 1, 66s.; No. 3, 61s.; Shotts, at Leith or Glasgow, No. 1, 72s. 6d; No. 3, 67s. 6d.; Carron, at Grangemouth, No. 1, 74s.; No. 3, 66s. per ton. There is a moderate demand for Scotch hematite pig iron, which is quoted 75s. for delivery at the West of Scotland steel works.

Shipments of Pig Iron.

The shipments of pig iron from Scottish ports in the past week were small, amounting to only 5071 tons, compared with 11,030 in the same week of 1906, showing a decrease of 5959 tons. The aggregate shipments since the beginning of the year still show an increase of 48,839 tons. The arrivals of Cleveland pig iron at Grangemouth in the past week were 16,261 tons, being an increase of 2924 over the quantity received in the corresponding week of last year. There is a total increase in these imports since 1st January amounting to 13,800 tons.

Finished Iron and Steel.

The recent reductions in the prices of finished iron and steel have not, so far as can be ascertained, added very materially

to the amount of employment. Several works are altogether idle, and others are working reduced shifts. Foreign material has been pressed for sale at a considerable reduction on home products, but it does not appear that much business has transpired. There is, indeed, a strong feeling in favour of the home manufacture, if it can by any means be rendered available. A considerable amount of steel is being delivered to shipbuilders under contracts placed some time ago. There is a quiet export business in both iron and steel.

The Shipbuilding Trade.

Comparatively little fresh work is coming forward in the shipbuilding trade. The report is revived that Messrs. William Beardmore and Co., of Clydebank, are to construct a number of warships for the Spanish Government. It is now stated that a sum of £7,000,000 is to be spent on these vessels, and while this amount is large in itself, it is pointed out that it would not provide many ships of the kind that are now classed as first-rate men-of-war. But the suggestion is made that a number of small craft is likely to be included in the contract. Work on this part of the Clyde is now so much reduced, and so many workmen have been discharged, that it is much to be desired that the Spanish contracts should come to the district.

The Coal Trade.

The past week's coal shipments at Scottish ports amounted to 318,660 tons, being 47,239 more than in the preceding week, and 55,326 tons above the quantity despatched in the corresponding week of 1906. Current demand for shipment is fair, and prices are maintained. At Glasgow Harbour, ell coal is quoted 13s. to 13s. 6d., steam 13s. 3d. to 13s. 9d., and splint 14s. 6d. to 15s. per ton. House coal has been selling more freely for home use, owing to cold weather, and there is a fair business in manufacturing qualities. The Scottish colliers, who asked a further advance of 18¾ per cent. in their wages, have declined an offer of 6½ per cent., and the matter will be further considered next week at a meeting of representatives of employers and workmen, under the presidency of Lord Ardwall.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Welsh Coal Trade.

THE buoyancy which has characterised the trade of late shows no signs of lessening, and it will be seen that prices indicate distinct firmness, and probably an advance. The boom has not been confined to one part: for while Cardiff and its district has enjoyed the lion's share, Newport was unusually brisk, and last week despatched the large item of 110,262 tons, of which over 91,000 were for foreign destination. Swansea, again, had a large total—92,206 tons; the minor ports being busy, Port Talbot, which is forging ahead, despatching 28,942 tons foreign and 5775 tons coastwise. Llanelly, too, is flourishing, and new companies are forming. The latest issue from the Cardiff Exchange was to the effect that the market was strong, and prices advancing. It was stated this week that for certain best coal 20s. had been paid, and quotations show how near this is to ruling prices, while the healthy state of all coals is evident. The spectacle at the leading docks is very promising, and even those who regarded the boom as past are forced to the conclusion that trade is safe up to the holidays, and may be still greater, temporarily, by the Yorkshire difficulty. Latest quotations on 'Change, Cardiff, are:—Best large steam, 19s. 3d. to 19s. 6d.; best seconds, 18s. 6d. to 19s.; ordinary seconds, 17s. 3d. to 18s. 3d.; best drys, 19s. to 19s. 6d.; ordinary drys, 17s. 9d. to 18s. 6d.; best washed nuts, 14s. 9d. to 15s. 3d.; seconds, 14s. to 14s. 3d.; best washed peas, 13s. to 13s. 3d.; seconds, 12s. 6d. to 13s.; very best small, 11s. 3d. to 11s. 9d.; best ordinaries, 10s. 3d. to 10s. 9d.; seconds, 9s. 6d. to 10s. 3d.; inferior sorts, 8s. 6d. to 9s. Very best Monmouthshire, black vein, 17s. 9d. to 18s.; ordinary Western Valleys, 17s. 3d. to 17s. 9d.; best Eastern Valleys, 16s. 6d. to 16s. 9d.; seconds and other sorts, 15s. to 15s. 6d. Bituminous coal: Best households, 19s. 6d. to 20s. 6d.; best ordinaries, 17s. 6d. to 18s.; No. 3 Rhondda, 19s. 6d. to 20s. 6d.; brush, 16s. 6d. to 17s.; smalls, 13s. to 13s. 6d.; No. 2 Rhondda, large, 15s. to 15s. 6d.; through, 11s. 6d. to 12s.; smalls, 9s. 3d. to 9s. 6d.; patent fuel, 18s. to 18s. 6d.; coke, 19s. 6d. to 27s.; pitwood, 22s. 6d. to 24s. Large cargoes are steadily coming in—nine cargoes in one day.

Large Shipments of the Week.

There was a very fair start this week at Cardiff. On Monday the quantity of tonnage in the docks waiting to be cleared was a good indication of the existing pressure for supplies. There were 30 steamers in waiting, many of large size, and the collective tonnage was only a little short of 67,000 tons. One vessel carried 7000 tons cargo.

Anthracite.

The vigour in the steam coal trade is shared by the anthracite, and hopeful conditions prevail at Swansea and Llanelly. In the latter district the Dynant Company has been registered, and near at hand the Caeglas Company is reported in the last few days to have struck a rich seam. Anthracite in Swansea is in large and steady demand, and for some descriptions demand is greater than the supply. Machine samples are brisk, and red vein active. Latest prices this week:—Best malting, 28s. to 29s. 6d.; seconds, 26s. to 27s. 6d.; big vein, 24s. to 25s.; red vein, 20s. to 21s.; cobbles, 29s. to 29s. 6d.; nuts, 27s. 6d. to 29s. 6d.; peas, 15s. 6d. to 16s. 6d.; rubbly culm, 8s. to 8s. 6d.; duff, 5s. to 5s. 6d. Other quotations, Swansea, are:—Best steam, 17s. 6d. to 19s.; seconds, 16s. 6d. to 17s. 6d.; bunker, 12s. 3d. to 12s. 9d.; small, 8s. 6d. to 9s. 6d. Bituminous coal: No. 3 Rhondda, 20s. 6d. to 21s. 6d.; through, 14s. 6d. to 15s.; small, 11s. to 12s. Patent fuel, 16s. 6d. to 17s.

Swansea Trade.

Last week, stated on authority, was almost the best we have had. Total imports and exports 133,757 tons, or an increase of 48,000 tons compared with the corresponding week of last year. France figured for 48,270 tons; Italy, 19,811 tons. Patent fuel imports were not very large—7918 tons. Swansea used to have the principal, but other ports run it closely.

More Docks for Cardiff.

It used to be a favourite speculation of the late Mr. Talbot that the shore from Neath to Swansea should be docked, and, however seemingly visionary at the time, the idea has had supporters since. Now authorities are contending that in the near future Cardiff will require more docks, and a vision of the distance is—docking the expanse between Newport and Cardiff. The contention is that in five years hence Cardiff may have an export of from three to five million tons more than at present, and the question will be: Where is the dock expansion to meet it? The new dock at Cardiff will meet a good deal, and Newport, as the great outlet from the New Rhondda, will aid considerably. Newport extensions are in vigorous hands, and marked progress is now being made there.

Doubling the Line, Manchester to Milford.

This additional enterprise of the Great Western Railway is now to be constructed between Carmarthen and Aberystwith. It promises in time to be of much importance. Great tracts of peat abound, and scientific tests are going on with the object of making it a flourishing commodity.

The Graig Waterworks at Swansea.

The cost of this scheme has just come out in financial accounts, and totals, up to the present, £554,490.

Iron and Steel.

Heavy steel rails and sleepers continue to figure at the leading works, a large proportion coming from Dowlais, while Cyfarthfa, Ebbw Vale, and Blaenavon, maintain average conditions. I note that this week a large cargo of rails was shipped foreign from Cardiff, 5270 tons, and two cargoes steel came to Newport from Antwerp. Swansea received a cargo of pig iron from Harrington, and one from Whitehaven, and Briton Ferry a cargo from Harrington. In all, last week, Swansea imported 1250 tons pig iron, 1130 scrap steel, and 1575 iron ore. The furnaces at Baldwin are maintaining a good output of pig. Large quantities of iron ore continue to arrive, principally from Bilbao, but Ebbw Vale this week received a cargo from Seville. It will be seen from quotations given by the Swansea Metal Exchange, that there is not much alteration in prices. Quotations are:—Hematite mixed numbers, 67s. 9d.; Middlesbrough, 49s. 9d.; Scotch, 60s. 6d.; Welsh hematite, 77s. 6d. Steel bars: Bessemer and Siemens, £5 5s. Steel rails, no quotations given out. Iron ore: Cardiff and Newport, Almeria, 16s. 3d. to 16s. 6d.; Rubio, 16s. 6d. to 17s.

Tin-plate.

Last week one large tin-plate works was idle, but the rest were all in active operation, and matters at Swansea fairly brisk, while at Llanelly, Lydney, and the Monmouthshire works an average condition was well maintained. During the week the weather was not favourable to despatch, and the total shipments scarcely reached 60,000 boxes, and the quantity received from the works was confined to 63,335 boxes. Stocks at present are 130,871 boxes. There is a movement on foot, and strongly supported, for the fixing of a minimum price for tin plates. In support of this scheme, it is publicly stated that quantities have been sold of late at unremunerative prices, and the effect of this has told badly on trade, buyers having been induced to "hold back" in the hope of larger concessions. Latest prices have been as follows:—Ordinary sheets, Bessemer and Siemens, 13s. 3d. for I.C. 20 × 14 × 112 sheets; ternes are a little lower, 28 × 20 × 112 sheets, 24s. 9d.; C.A. roofing sheets, £10; big sheets for galvanising, £10; finished black plates, £10 to £10 5s.; galvanised sheets, 24 g, £13 2s. 6d. Other quotations, Swansea, are: Block tin, £138 10s.; copper, £61 15s.; lead, £17 10s.; spelter, £21 7s. 6d.; silver, 26⅝d. per oz. Copper market sluggish, but the copper works are all busy, and in spelter demand has outrun supplies. Nickel works are in full drive.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, November 14th.

THE iron and steel output is being heavily curtailed by all the greater producers in view of the uncertain conditions surrounding the trade. Thousands of labourers have already been discharged. This does not mean the industry is in a dangerous condition, because nearly all of the mills have business that will occupy a good deal of their capacity during the coming year. The expansion in productive capacity that has been created within the past few months is the cause of the present curtailment indirectly. This expansion was provided on the theory that the phenomenal demand would continue. The steel makers exercised sound judgment from their point of view, but they did not discount, or rather, anticipate the present financial conditions, nor the effect of the crusade of the general Government against great combinations of capital. It is this latter condition that has upset calculations and which has led to the general modification of the policy of manufacturers. Quite a number of furnaces are about to be blown out. Some have been blown out for repairs and a few because the margin of profit is not sufficient. It is the opinion of a good many that the corner will soon be turned, but that depends upon the re-establishment of confidence, and that confidence depends upon a pretty thorough reorganisation of our monetary system. Various conferences of steel manufacturers have been held, and a policy of curtailment was decided to be advisable in the present condition of things. No attempt has been made or will be made to control prices, but output will be reduced to such an extent that prices will probably remain where they are to-day. Steel plants in the east have reduced output about one-half. It is firmly believed that the railroad companies will soon be large buyers, and this influence will do much to restore confidence. The policy of curtailment which has been decided upon within a few days will produce effects within the next month. A dozen furnaces are to be closed down in the Pittsburg district. The steel makers are determined that nothing shall occur to force prices below what they are at present. The structural mills are anxious for business, but there will be no cutting of prices to induce it. There is a large tonnage of steel bars on the books at the mills, and prices are 1·60 at mill, and there the price will stand. In other branches of the industry the demand is steady, such as in merchant bars, sheet iron, pipes and tubes, merchant steel, and in tin-plate.

The copper situation is about as a week ago. Production is proceeding at the rate of about 45,000,000 lb. per month, and the imports at the rate of about 20,000,000 lb. It is necessary to keep in sight that of the 50,000 tons of copper exported to China during 1905-6, 40,000 tons came back to Europe and America during the past twelve months. Tin has broken under the severe strain to which it has been put. Only about 29 per cent. of the tin mills capacity of the American Sheet and Tin-plate Company are at work. This means a lessened demand should this policy continue. The latest announcement is that a European syndicate has purchased 50,000 tons of copper, but the genuineness of the report is doubted. Very little actual business has been done with European consumers. The whole situation is disturbed, and a definite statement is impossible.

NEW YORK, November 21st.

The action of the Government in coming to the rescue of the financial and business interests has created a general spirit of confidence, and although the announcement has only permeated the surface of business, already the results are visible. Reactionary influences are already at work. The total outcome of the action of the Government cannot be predicted with very much certainty, but the effect will be beneficial. Within twenty-four hours inquiries have been received by some of the larger manufacturing interests represented here as to prices for steel for new work, or rather for work that has been held in abeyance for two or three months past. A contract has just been placed for the Brooklyn Subley loop calling for 26,0 tons of steel. Two or three eastern railway systems have this week placed orders for lots aggregating perhaps 3000 tons. There are also inquiries from other quarters. The closing down of some shipyards, manufacturing plants and foundries has led to a postponement of deliveries, but it is probable that orders will soon be placed for the delivery of that material. About 40 per cent. of the 260,000 tons of material on the books of the American Bridge Company are for railroad work. A good deal of the material ordered is for steel-making plants. The great open-hearth plant and the rail mill, the blast furnaces and the power-house of the great plant at Gary, Indiana, are now completed. The United States Steel Corporation, with its long-headed management, is pushing ahead filling the large batch of orders on its books which were countermanded a month ago, having confidence that the material will be wanted about the time ordered. Smaller concerns are shutting down instead of taking such chance, and accordingly announcements are being frequently made of suspensions or of restrictions of work. Now business is very light in all directions, but it is believed that with the restoration of confidence there will be a resumption of something like former activity.

The Geological Survey has recently completed its estimate of the readily available ores in the four southern States, Alabama, Georgia, Tennessee, and Virginia, which shows a supply of 2,500,000,000 tons of rich ores. It is estimated that the total reserve of ores of the Southern States is 10,000,000,000 tons.

Refined copper took a turn downward and Lake sold to-day at 13 c., electrolytic at 12⅞ c., and casting at 12½ c. Total exports from Atlantic ports since November 1st. are 16,861 tons. Imports have been unimportant. The copper trade is in a dull condition, but very little can be said of it. Shipments are going forward at the rate of 100 tons per day which means about 125,000,000 lb. during the last two months of this year. European consumption averages about 20,000 lb. per month, only part of which comes from this country.

LAUNCHES AND TRIAL TRIPS.

AFRIQUE, steel twin-screw steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of the Compagnie de Chargeurs Réunis, of Paris and Havre; dimensions, 408ft. 0in. by 48ft. 4½in. by 27ft. 9in.; to carry 3000 tons; engines, triple-expansion; constructed by the Wallsend Slipway and Engineering Company, Limited; launch, November 20th.

IBIAPABA, twin-screw steamer; built by Messrs. Craig, Taylor and Co.; to the order of the Lloyd Brazileiro; dimensions, 286ft. by 44ft. 9in. by 17ft. 6in; engines, triple-expansion, 14in., 22in., and 37in. by 24in.; constructed by Messrs. Blair and Co.; launch, November 21st.

SPREEWALD, steel screw passenger steamer; built by Messrs. Furness, Withy and Co.; to the order of the Hamburg-Amerika Line; dimensions, 366ft in length; engines, triple-expansion, 25½in., 43in., 72in. by 48in., pressure 200 lb.; constructed by Messrs. Richardsons, Westgarth and Co.; launch, November 21st.

SAINT ANDRE, steel screw steamer; built by the Ateliers et Chantiers du France, Dunkirk; to the order of the Société Navale de l'Ouest, Havre; dimensions, 286ft. by 39ft. by 28ft; engines, triple-expansion; constructed by the builders; launch, November 21st.

LUNA, steel screw steamer; built by the Clyde Shipbuilding and Engineering Company; to the order of the Navigazione Libera Triestina Societa in Azioni of Trieste; dimensions, 315ft. by 46ft. 6in. by 23ft. 4½in.; constructed by the builders; launch, November 23rd.

FREIRE DE ANDRADE, twin screw cargo and passenger steamer; built by Earle's Shipbuilding and Engineering Company; to the order of Carlos Augusto Pereira Limitada, of Lisbon and Delagoa Bay; dimensions, 125ft. by 25ft. by 9ft. 6in.; engines, compound, pressure 180 lb.; constructed by the builders; launch, November 25th.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MESSRS. MANLOVE, ALLIOTT AND CO., Limited, engineers, Nottingham, inform us that Mr. J. Arthur Reavell has left their employment.

MESSRS. ANDREW BROWN AND CO., of 110, Cannon-street, E.C., have been appointed the agents for Messrs. Urquhart, Lindsay, and Co., Limited, Blackness Foundry, Dundee, makers of machine-moulded wheels, machine-cut gearing, shafting, and gearing of all kinds.

MR. GEO. A. BECKS, of 4 and 5, Queen Anne's-chambers, Westminster, asks us to state that he has been appointed to represent the interests of the Irwell Steel Foundry Company, of Manchester, and also of Mr. John T. Brooker, British-grown Timber Saw Mills, and contractor for compressed railway keys and trenails.

MR. MONTE CALLOW, late of Ipswich, has closed his business at Ipswich and joined the firm of Marples, Leach and Co., of 6, Victoria-avenue, Bishopsgate-street Without, who will continue to sell his specialities, in addition to their dynamos, motors, fans and general accessories.

MESSRS. G. STEPHEN AND SON, of 29, Castle-street, Dundee, intimate to us that Mr. Alexander Stewart Rae, junior, and Mr. George Stephen Rae, both sons of Mr. Alexander Stewart Rae, sole partner of the firm of George Stephen and Son, who have been associated with him in the business for many years, have been assumed as partners from the 1st inst.

THE New Speedwell Motor Company, Limited, advises us that it is now moving into its new works at Feltham, and that all letters should from henceforth be addressed to:—The New Speedwell Motor Company, Limited, Feltham, Hounslow, W. The head offices of the company are also being transferred to Feltham; therefore, all communications of whatsoever nature should be addressed as above.

HEENAN AND FROUDE, Limited, of Manchester, have opened offices at 56, Victoria-street, London, S.W., under the control of Mr. Robert H. Hammersley Heenan, M. Inst. C.E., M.I.E.E., who, having recently retired from the position of general manager and engineer-in-chief, Table Bay Harbour and Docks, under the Cape Government, has now joined the board of that company. Messrs. J. B. Corrie and Co., of 4, 5 and 6, Queen Anne's-mansions, Westminster, will continue as heretofore to act as this firm's agents in London for South America and other foreign countries.

CUNARD TENDER SKIRMISHER.—On Saturday last the Cunard twin-screw tender resumed her work in the Mersey after having been in the hands of Messrs. David Rollo and Sons, of Fulton Engine Works, Liverpool, who have fitted her with two new steel boilers, each 12ft. 9in. diameter by 10ft. long, each having two Morison furnaces 44in. internal diameter, the total grate area being 80½ square feet and the heating surface 2870 square feet; the working pressure is 100 lb. per square inch. The vessel has undergone an extensive overhaul both to hull and machinery, and a new bridge deck has been added. The work was carried out to the specification and under the supervision of the Cunard Company's general superintendent, Mr. James Bain, assisted by Mr. George Thompson, the superintendent engineer, Mr. Peskett, naval architect, and other members of the Cunard staff.

CONTRACTS.—Amongst the orders which the Cryselco Company has recently received is one for the lamps for his Majesty the King's new yacht Alexandra.—The Bury St. Edmunds Borough Council have decided to accept the tender of Messrs. Heenan and Froude, Limited, of Manchester, Worcester, and London, for the erection of a two-cell destructor, to be capable of dealing with 30 tons of refuse per day of 24 hours.—The Mirrless Watson Company, Limited, has recently secured an order for a complete new cane sugar factory to be erected in the state of Morelos, Mexico. This plant consists of two Babcock and Wilcox water-tube boilers, a six-roller mill with rollers 26in. by 48in. driven by a 22in. by 42in. engine, and so arranged that additional mills and Krajewski crusher can be added at an early date. The usual sulphuring and defecating arrangements are provided, and filter presses for scums, and bag filters for syrups. The triple effect has 3800 square feet of heating surface, and is of the Hagemann type. There are two coil vacuum pans, each striking 30,000 lb. sugar, which is cured by eight 30in. Weston centrifugals. The condensing plant consists of two barometric condensers, with dry air pumps, each 21in. diameter by 18in. stroke. The necessary steel buildings with overhead traveller in mill house, and a well-equipped machine shop, are also being supplied.

NOTES FROM GERMANY.

(From our own Correspondent.)

Quiet Trade in Rheinland-Westphalia.

BUSINESS on the iron and steel market has been of small proportions generally; the mills, being anxious to secure employment, are willing to take in work at very low prices, and this has been the cause of much underquoting on the part of makers and dealers. Prospects for the future are uncertain and, some say, unfavourable, the dearness of money having considerably reduced the means of speculative business. The railway and engineering department is about the only branch of the iron industry that has not yet been affected by the general depression. A most satisfactory activity is going on at the various establishments; some of them are actually crowded with work, and a delivery in three months is not an exception. Prices, too, in this department are remunerative, and concessions are only in special instances agreed to. The German hoop mills on the 17th inst. reduced the prices for hoops by M. 10 p.t., the present quotation being M. 140 p.t.

Sales of the Steel Convention.

In October of present year 438,933 t. have been so'd, which is 19.310 t. more than in September last, when sales were 419,623 t. When compared with October last year, with 501.562 t., a decrease of 62,629 t. is shown. Deliveries in semi-finished steel during October were 12 014 t., as against 125,291 t. in September, 1907, and as compared with 158,284 t. in October, 1906. Railway material, 188 998 t., as against 176 973 t. in September and 176,974 t. in October last year. Sectional iron, 129,921 t., as against 117,359 t. in September, 1907, and as compared with 166,304 t. in October, 1906.

Iron in Silesia.

Trade generally was languid last week. There is a disinclination to buy, except from hand to mouth, and only small contracts are placed at present; heavy orders are being put aside, it appears, till a more favourable period. Good accounts continue to be given concerning employment in the engineering trades; the amount of work secured hitherto has been sufficient to keep the shops in regular occupation for a while. On the whole, the outlook is not favourable as regards general employment, but there are some branches still that can boast of being well provided with work, and if quotations have, here and there, been inclined to decrease, some articles, on the other hand, have shown a good deal of firmness.

Production of Pig Iron.

According to official statements given by the Union of German Iron and Steel Masters, output of pig iron in Germany, including Luxemburg, was 1,138 676 t. during October, as against 1.091,020 t. in September, and compared with 1,073.874 t. in October, 1906. During the period from January to October of present year, 10.827.160 t. pig iron were produced, as against 10 346,857 t. in the same period of last year. Regarding the different sorts of pig iron, 38 308 t. were Bessemer pig iron, as against 44 452 t. in October, 1906; 740,912 t. basic, as compared with 693,052 t.; 90.418 t. steel and spiegeleisen, as against 82,232 t; and 63,993 t. forge pig, compared with 79,922 t. in October, 1906.

Coal in Germany.

The coal trade over here could not possibly be in a more animated position than at present, demand being vigorous and deliveries heavy, only the scarcity of wagons preventing a more extensive business from being done. In Silesia Russian coal is being freely bought, home supplies proving insufficient. The production in coke is also far behind consumption. The United Lower Silesian Coal Pits resolved on a rise of 2 and 7 pfennigs p.q. for all sorts of coal bought at the pit's mouth from November 15th of present year. October deliveries in coal, coke, and briquettes in the Ruhr district were 5,856 210 t., or 216,900 t. per day, as compared with 5,471,780 t., or 200,650 t. per day, in the same period last year, which shows an increase of 7 per cent. In Upper Silesia deliveries from the 1st to 31st of October of present year were 2,085,120 t., as against 1,898,820 t. in the same month last year; in the Saar district 692.320 t, compared with 748,120 t.; and in the three districts together 8,633,660 t., as against 8,113,620 t. in the same month of the year before.

The Austro-Hungarian Iron Market.

Less work is being done in building material than previously, and business in the manufactured iron department is also inclined to weakness. Some specially favoured shops have been able to secure work which will last them till the end of the first quarter in 1908, but there is not much speculative business being done generally. All descriptions of fuel are in strong demand in Austria-Hungary, but so long as the scarcity in wagons continues the pits cannot fully profit by the present animated condition of the coal trade. The steadily rising demand for engine fuel has led to an advance in prices. English coal has been bought freely by Hungarian ironmasters. From Rheinland-Westphalia, also, 50,000 q. have recently been imported, the local supplies being far behind requirements.

Weak Tone in Belgium.

The depression in the malleable iron business, and the steadily decreasing quotations in that department, have not been without influence on the pig iron market, and the falling off in quotations that had been expected for some time already has now taken place. Forge pig has met with a reduction of 4f. p.t., foundry pig 2f. p.t., and basic 0·50f. p.t. Girders, being in satisfactory demand, have been able to maintain the old price of 148·75f. p.t. f.o.b. Antwerp for export, and 167·50f. p.t. for home consumption. Orders for rails have been coming in pretty regularly of late, and the shops, therefore, have been kept in good employment. Plates are dull, but further reductions in price have not been reported since the beginning of October. There is absolutely nothing of interest to be related of the Belgian coal market, the former strong tone prevailing generally. House coal has become so scarce that a rise of 1f. and 2f. p.t. had already taken place at the end of last month.

LOUGHBOROUGH'S NEW DAM.—The new reservoir of the Loughborough Corporation in Charnwood Forest, as a result of the recent snowstorm, began to overflow for the first time on the 25th inst. through the waste-weir arches of the dam, in the form of a cascade, into the still-water pond, 65ft. below. The reservoir has a capacity of over 500 million gallons, and the daily observations show that there is no trace of any water escaping either through or past the dam, which was constructed of cement concrete and masonry, the water-face being lined with blue brick in cement. An unusual feature in connection with the work was that, in order to relieve the scarcity of the existing supply to the town, when the dam had reached the height of 42ft. 6in. the water of the brook was temporarily stored to a height of 40ft. while the upper portion of the dam was being completed. Besides being quite water-tight, the dam is also claimed to be one of the cheapest that has been made, the cost of the undertaking being a little over £100,000. Under the advice of the consulting engineers, Messrs. George and F. W. Hodson, of Loughborough, all the water rights of the stream were purchased, and the only compensation water let down is 30,000 gallons per day for agricultural purposes. The Corporation have therefore at present a large surplus of water, which they have agreed to sell to Leicester until the Derwent supply is ready.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS**, *M.I.Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

3286. February 9th, 1907.—IMPROVEMENTS IN STEAM INJECTORS FOR SUPPLYING FEED-WATER TO BOILERS AND THE LIKE, Robert G. Brooke, of Upton Grange, Macclesfield.

This invention relates to steam injectors of the type wherein a gap or supplementary overflow between two portions of the combining muzzle is automatically closed on the starting of the injector by a closing device that is free to slide on the lower or forward portion of the combining nozzle. There are six figures. Fig. 1 shows a longitudinal central section. *a* is the water inlet branch, *b* the steam nozzle, *c* and *d* the two parts of a divided combining nozzle, and *e* the delivery nozzle of the injector. *j* is a tube, mounted to fit closely and slide endways upon the part *d* of the combining cone. Arranged between the lower or forward part *d* of the combining nozzle and the delivery nozzle *e* and within the injector casing is an overflow chamber *f*, the upper or rear wall *g* of which has holes or passages *k* which may be arranged parallel

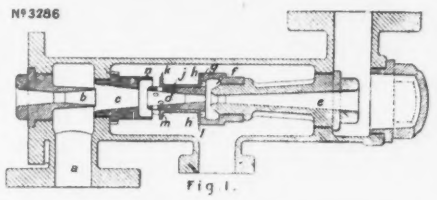


Fig 1.

to the line of flow of the jet of water and steam flowing through the injector. The upper or rear surface of the wall *g* of the chamber may be in the form of a flat seating, and against it the tube *j* can rest when the injector is not operating. The tube is free to slide on whilst closely fitting the portion *d* of the combining nozzle, and is provided at its opposite ends with flanges *k* and *l*. The flange *l* closes the opening *k* in the overflow chamber *f* when the tube *j* is in its lowered position, or in the position furthest away from the supplementary gap or overlap *m*, and the other flange *k* is forced into close contact with a single seating *n* to close the gap overflow *m* when the injector is started, and the tube *j* raised or moved by the action of the overflow water passing through the passage *k* and impinging against its adjacent flanged end *l*.—*November 11th*, 1907.

7729. April 2nd, 1907.—IMPROVEMENTS IN VALVE GEAR, *Wilhelm Platz, of 27, Bahnhofstrasse, Weinheim, Baden.*

This invention relates to improved gear for steam engines, and consists in a valve controlling device for double-acting steam cylinders wherein the two inlet and the two outlet valves, arranged at the side of the cylinder and in pairs upon two rods, are controlled by the rods without the employment of oscillating or rotary discs, cams, or rollers. There are three figures. Fig. 1 is a

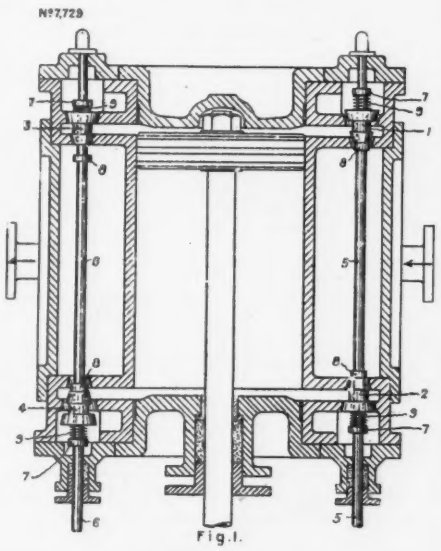


Fig.1.

diagram of the valve gear applied to a steam engine cylinder, in which the steam inlet is on one side and the steam outlet on the other side. The valves 1, 2, 3, 4 are loose upon the rods 5 6, by which they are moved. Upon these rods are collars 7, 8, designed for opening and closing the valves. Between the collars 7, which close the valves and the valves themselves are arranged springs 9. The rod 6 carrying the outlet valves 3 and 4 is firmly connected with the valve mechanism—not shown—whilst the rod 5 carrying the inlet valves 1 and 2 may be moved by means of a link or a shaft governor, in order to obtain a variable expansion. The springs 9 permit of a continued movement of the rods 5 and 6 when the valves have already reached their seatings. Moreover, the springs 9 permit of the lead of one valve with respect to another, and a spring at one end of the rod acts as a buffer for the collar provided at the other end to open the valve.—*November 14th*, 1907.

14,989. June 29th, 1907.—IMPROVEMENTS IN STEAM EJECTORS FOR SUPPLYING FEED TO BOILERS AND THE LIKE, Henry Lea, of 38, Bennett's Hill, Birmingham.

In injectors of the flap nozzle type, in which the combination cone is split longitudinally, one half being a fixture and the other half a hinged flap, which flap flies open to the first rush of steam, and afterwards closes when the advent of the water causes a partial vacuum in the combining cone, the junction between the flap and the fixed portion has hitherto been made a straight line. In this invention the junction consists of a segment of a circle, whereby the manufacture of the injector is considerably simplified and cheapened. There are three figures. Fig. 2 is a section. C is the fixed portion of the combining cone, in which the recess

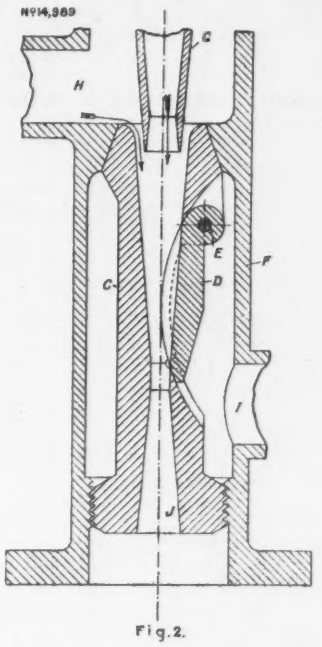


Fig.2.

has been cut, and D is the flap, hinged upon the pin E. F is the casing of the injector, G is the steam cone, H is the water inlet, I is the overflow, and J is the delivery cone.—*November 7th*, 1907.

TURBINES.

23,123. October 18th, 1906.—AN IMPROVED INTERNAL COMBUSTION HOT AIR TURBINE, *Pietro Ghelli, of Avellino, Italy, and Carlo Gusberti Gazzani, of Savona, Italy.*

This invention relates to a thermic motor in which the motive fluid is air, which is subjected to suitable pressure and raised to a high temperature, and actuates a rotary engine in which its temperature is kept constant by the combustion of gaseous or previously vaporised liquid fuel. There are four figures. Fig. 1 is a longitudinal section. The two turbines *a b* are mounted on the same shaft, the first of which acts as compressor, and the second as motor. Each of these turbines is enclosed in a casing, and is

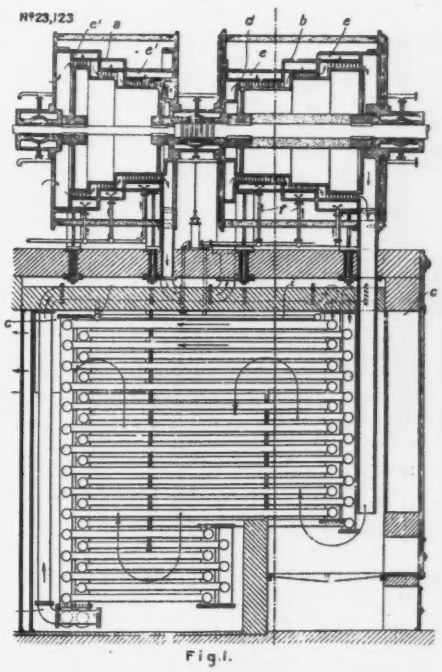


Fig.1.

composed of a large number of vanes and several series of directing or stationary vanes, so that the motive fluid issues from one line of the vanes, enters the stationary vanes of the following line, and then passes to meet the movable vanes of the next to rotate the turbine. The parts of the drums on which the different series of vanes are arranged are not all of the same diameter, but are arranged in two, three, or more than three steps or stages, and each of these stages is provided with vanes, the circles containing the peripheral edges of which are of equal diameter, but of different diameter to those of the vanes of the other steps or stages. The diameters of these stages, from the entry of the air into the turbine to its issuing therefrom, progressively increase in the driving turbine and diminish in the compression turbine. The hot air comes from the tubes of the regenerator *c*, and enters the turbine, passing through the double automatic valve, which serves for keeping the pressure of the air constant. The air first passes through a throttle valve, and when of sufficient pressure, raises a loaded valve. The hot air then acts on the first stage or series of vanes, and from there successively on all the following ones. In order to keep the air at the higher temperature whilst it is performing its work in the turbine, combustible fluid is injected into the latter. The cylinder or drum *d* which carries the stationary vanes of each series or stage is surrounded by a chamber *e* in which openings are formed by which the inner space of the chamber *e* communicates with the interior of the turbine at the various stages. The number of these openings corresponding to each stage varies proportionally to the difference of pressure

between the chamber and the turbine, and for each stage varies relatively with the work done in the preceding stage. The chamber *e* is divided into annular compartments separate from each other, and corresponding to each stage of the turbine. The combustible gas enters the chamber *e* through the pipes *f*, at the beginning of which there is a special automatic valve for reducing the pressure of combustible fluid and regulating the introduction.—*November 8th*, 1907.

INTERNAL COMBUSTION ENGINES.

24,565. November 2nd, 1906.—IMPROVEMENTS IN INTERNAL COMBUSTION AND OTHER FLUID PRESSURE ENGINES AND THE LIKE, David Roberts and Charles James, of Spittlegate Ironworks, Grantham.

This invention relates to internal combustion engines of the trunk piston multi-cylinder vertical enclosed type. There are five figures. Fig. 1 is a transverse sectional elevation of a portion of a vertical engine, provided with means for closing the oblong opening in the diaphragm through which the connecting-rod passes. *a* represents the bed plate of the engine, *b* the column, *c* the cylinder, *e* the crank shaft, *f* the connecting-rod, *g* the piston, *h* the oblong hole through which the connecting-rod *f* passes, and *i* the diaphragm separating the upper and lower parts of the crank-chamber. *j j* are a series of plates which are superposed so as to form a shutter, the topmost plate being formed with a hole provided with a boss or die *k* through which passes the connecting-rod which is made parallel for the whole of its length. The plates or shutters which slide in the guides are of different lengths, and

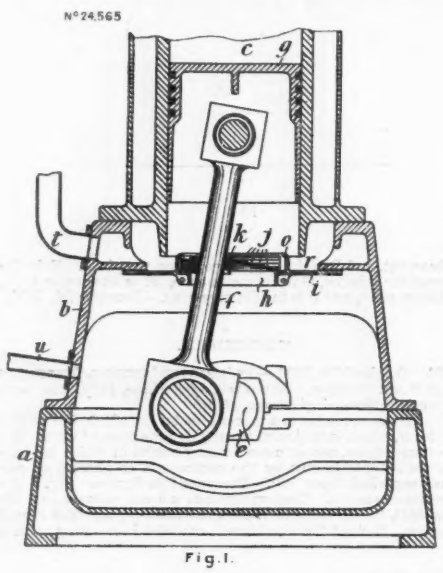


Fig. 1.

are provided with oblong holes, also of different lengths, the dimensions of the plates *j*, and of their holes, being such that as each plate is displaced laterally by the rod *f* it moves through only a portion of the total movement of the connecting-rod, that is to say, the shutter is expanded or contracted on the two sides of the connecting-rod *f* as the latter reciprocates. *o* is a lip which is carried around the plates *j j* to trap any oil that may possibly work through them from the crank-chamber, such oil being returned to the crank-chamber by a pipe. *r* is a well or space into which the dirty or waste lubricating oil from the piston *g* is collected, this oil being prevented from running back into the lower part of the crank-chamber by the lip *o*, and draining away through a pipe to the outside of the crank-chamber, where it is collected in any convenient way, *t* and *u* are ventilating pipes, the former fitted to the upper part and the latter to the lower part of the crank-chamber. These pipes allow for the displacement of air due in the lower part of the crank-chamber to the displacement of the piston.—*November 7th*, 1907.

25,051. November 7th, 1906.—IMPROVEMENTS RELATING TO THE GOVERNOR MECHANISM OF EXPLOSION MOTORS, *Daimler Motoren Gesellschaft, of Unterturkheim, near Stuttgart.*

The invention relates to multi-cylinder explosion motors in which the governing shaft is arranged in front of and beneath the cylinders. Fig. 1 is an elevation partly in section. The governor shaft *b* is situated, as usual, in front above the motor shaft. The

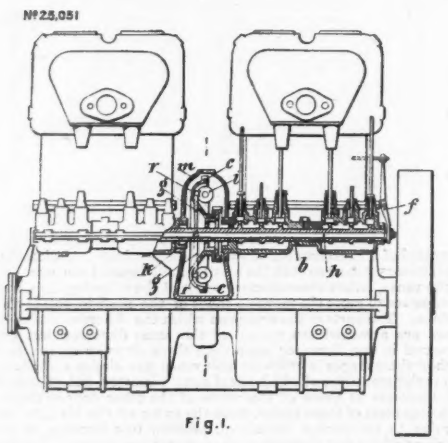


Fig. 1.

wheel *c* containing the speed governor shaft *b* on the motor shaft is arranged between two of the cylinders or pairs of cylinders, and surrounded by a suitable casing *m*, which is joined to the casing *n* of the motor shaft. To transmit the speed governor motion to the governor lever *f*, the governor shaft *b* is made hollow from the seat of the governor wheel to its end, and contains the spindle *h*, carrying a pin *k* passing through slots formed diametrically in the shaft *b*. The rocking shaft *r* of each of the two speed governor weights *i* is provided with a radial arm *g*, which arm engages the ends of the pin *k* projecting from the shaft *b*, so that the up-and-down movement of weights moves the spindle *h* to and fro in accordance with the action of centrifugal force and of the fitted tension springs both acting on the weights *i*. The end of the spindle *h* actuates the lever *f*, and this lever operates the gas admission valve. The governor shaft *b*, together with the governor wheel *c*, is surrounded by a two-part casing *m*, completely closed, and so constructed that when its top part is removed the whole of the governor mechanism is exposed. The arrangement of governor wheel described has advantages over that where the governor wheel is placed at the end of the governor shaft.—*November 7th*, 1907.

GAS PRODUCER.

342A. January 5th, 1907.—A COMBINED GAS PRODUCER AND AMMONIA OR EQUIVALENT GENERATOR, Clarke, Chapman, and Co., Limited, and John Robson, both of Victoria Works, Gateshead, Durham.

This invention relates to a combined gas producer and ammonia or equivalent generator. There are four figures. Fig. 1 is a sectional elevation. A protective liner 2 of any suitable material rests on the fire-grate 3, which, in turn, rests on the ring 4 riveted to the shell 5. 6 shows a flange riveted to the top of the shell 5. 7 is a casting bolted to flange 6, having an upper annular space 8, a lower annular space 9, and a groove 10 in the upper part of the partition between spaces 8 and 9, also a branch pipe 11 from space 8, and a branch pipe 12 from the central space 13. 14 is a coal-feeding hopper with slide 15, which can be opened or closed by a lever mechanism. 16 is a cover for hopper 14 with

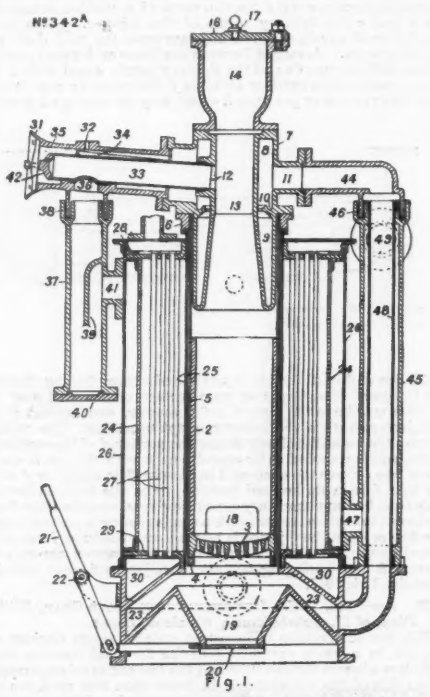


Fig. 1.

plug hole 17. 18 is an aperture through the liner 2 and shell 5, near the fire-grate, for extracting clinkers. 19 is a hopper below the grate 3, with a slide 20 actuated by lever 21, pivoted at 22, supported on the bottom casting 151. 23 shows an annular space outside of and open to hopper 19. 24 is the external wall of the boiler; 25 the internal wall. 26 is the outside casing of an annular space; 27 are the tubes; 28 the top, and 29 the bottom tube plate; 30 an annular space between the bottom tube plate 29 and space 23. 31 shows a tapered pipe; 32 a water pipe connection; 33 an internal pipe from pipe 12, having an external scroll baffle 34 in the annular space 35. 36 is a branch on pipe 33, joining the down pipe 37 by a mercury or other seal joint 38. 39 is a baffle in pipe 37; 40 shows a cover on the end of pipe 37. 41 is a branch on pipe 37, opening into the space between the casing 26 and boiler wall 24. 42 is a cover on the end of pipe 33. 44 is a pipe joining the pipe 11 to the vertical pipe 45, joined to the top of branch 43, and has a branch 47 near the bottom. 46 is a mercury or other seal joint. 48 is a pipe inside pipe 45, between pipe 44 and branch 43. 49 is a pipe leading to the jacket of an ammonia vapour receiver.—*November 7th*, 1907.

MINING.

23,947. October 27th, 1906.—IMPROVEMENTS RELATING TO ENDLESS ROPE HAULAGE, James W. Smallman, of Nuneaton, Warwick.

In endless rope haulage, if the rope breaks or accidents happen to couplings or clips, considerable damage may result from tubs running away. It is usual to guard against tubs that are being

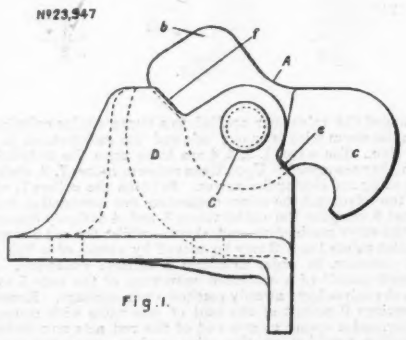


Fig. 1.

hauled uphill running back very far should they become accidentally released. Owing to such tubs, if released, reversing their direction of travel, no difficulty presents itself, for ordinary detents ("monkeys"), fixed every ten yards or so, and tripped by the axles of the hauled tubs, act quite effectively as stops. Tubs that are being held back downhill, if accidentally released, do not, however, change their direction of travel, and, consequently, ordinary detents ("monkeys") cannot be applied. It is therefore customary for tubs working downhill to be left unguarded against accident. The object of this invention is a device that will allow a tub going downhill to pass at the ordinary speed—about two miles an hour—but will stop the tub at a runaway speed. There are six figures. Fig. 1 is a side elevation of the device. In Fig. 6 the special detent has been turned over centre by a blow from the first axle of a runaway tub. Referring to the two figures, A is the preferred pattern of detent. This detent has a head *b* and a wide hook *c*. The bracket D is bolted to a sleeper or frame. The abut-

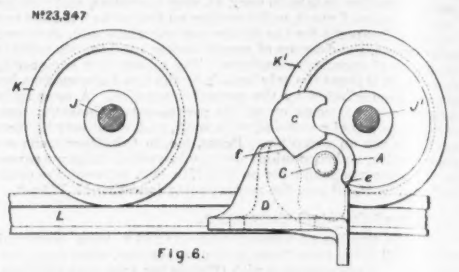


Fig. 6.

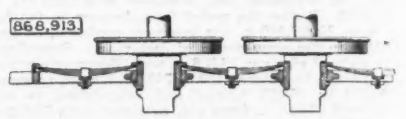
ments *e* on the bracket D are for the hook *c* to rest upon when the detent A is in its normal position; *f* are supports on the bracket D for the hook *c* when the detent A is turned over centre. C is the joint-pin, retained by a split cotter. J is the first axle of the tub, J¹ is the second axle. K and K¹ are two of the wheels running on the rail L. At the proper speed of the tub the axle J gradually depresses the head *b*, the detent A returning to its normal position under the influence of gravity. The detent A, during the passage of the axle J¹, again rocks idly, but the axle J of a runaway tub strikes the head *b* with sufficient force to fully trip the detent A. The hook *c* then beds against the supports *f*, receives the axle J¹, and stops the tub.—*November 7th*, 1907.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

868,913. CUSHIONING APPLIANCE FOR LOCOMOTIVES, *W. Dalton, Schenectady, N.Y., assignor to American Locomotive Company, New York, N.Y., a Corporation of New York.*—*Filed July 22nd*, 1907.

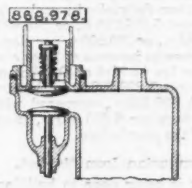
The nature of this invention will be readily understood from the



drawing. The wheels have considerable lateral play in hornplates, and are controlled by lateral springs, as shown, so as to give easy movement round curves. There are four claims.

868,978. EXPLOSIVE ENGINE, *M. Fischer, Zurich, Switzerland.*—*Filed February 27th*, 1906.

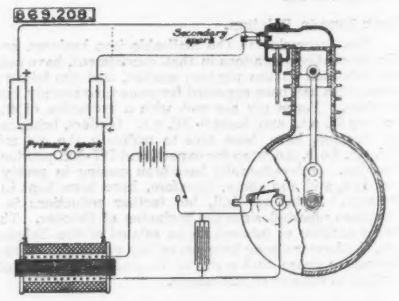
This invention consists in the combination with the working cylinder of an admission valve mounted on the working cylinder centrally above the piston chambers, a casing having on its outside



a deep annular groove to constantly hold fresh air circulating around the casing and cooling it, and a gasket of material which is a bad conductor of heat, arranged between the adjoining surfaces of the valve casing and the working cylinder. There ar two claims.

869,208. ELECTRIC IGNITION OF EXPLOSIVES, *O. J. Lodge and A. M. Lodge, Birmingham, England.*—*Filed April 10th*, 1903.

This invention consists in combining a low tension circuit, an interrupter in said circuit, a high tension circuit inductively



arranged with relation to said low tension circuit, a spark gap in said high tension circuit, condensing means placed in said high tension circuit, and adapted to discharge across said spark gap, a sparking plug forming a secondary spark gap disposed within the combustible mixture, means connecting said spark gap to the condensing means, and a connection normally keeping said sparking plug at the same potential. There are two claims.

RE-BOILERING OF A SPANISH LINER.—The steamer Santanderino, belonging to Messrs. John Glynn and Son, of Liverpool, has just sailed after having been laid up for some time, having two new main and donkey boilers fitted to her by Messrs. David Rollo and Sons, of Liverpool. Her propelling machinery has been generally overhauled and altered to suit the new conditions. Extensive alterations and renewals have been made to the hull, and the bunkers have been re-arranged. During the time the vessel was in the hands of Messrs. Rollo she was fitted throughout with a complete electric light installation of the most modern type. The whole of the work has been carried out to the specification and under the supervision of Messrs. George Hepburn and Son, consulting engineers of Liverpool, assisted by Captain Telleria, the company's marine overlooker, and Mr. George Barclay, its superintendent engineer.

NOVEMBER.

THE railway dispute, after attracting far more attention than it deserved for several weeks, came to a sudden end late on November 6th. Peace was brought about by the intervention of Mr. Lloyd George. The Board of Trade is not permitted to interfere in disputes unless it is invited to do so, and the President's meetings with deputations representing the railway companies and the men were nominally informal. However, they worked well enough, and an agreement was signed by both sides. Those who are interested will find the terms set forth in our issue of November 8th. They will see that the principle depended upon to prevent further trouble is the establishment of a series of Conciliation Boards. On these Boards agents elected by the men and representatives appointed by the railway companies will sit and discuss difficulties. In the event of the sectional and central Conciliation Boards failing to effect a settlement an arbitrator is to be appointed, and his decision will be final. It will be seen that Recognition, on the realisation of which the Amalgamated Society of Railway Servants had set their hearts, is not mentioned; quite the opposite, indeed, for all men, whether they belong to unions or not, have equal voting power in electing representatives. Under the circumstances it is not surprising that some of the more pronounced unionists have declared themselves betrayed. Certainly they have not got their way, but it becomes more and more evident, now that passionate utterances no longer inspire exaggerated views, that there never would have been a general and effective strike, and the grumblers have at least the satisfaction that the agreement has saved them from uselessly squandering their funds.

THE Indian railway strike has provided a very illuminating object lesson on what would have occurred had the companies and the men been allowed to fight it out. The strike began on the East Indian Railway on November 18th or 19th, and it lasted for about one week, causing a certain amount of delay and inconvenience at a few big junctions. It died out on that line, and was thought to be over, but broke out again a few days later on the Bengal - Nagpur Railway. It was obviously manipulated by agitators, and the firm attitude of the railway companies brought it quickly to an end. It was a futile performance, and, although it had the assistance of the enginemen, came to nothing. Who can doubt that the same fate would have overtaken the strikers in this country? By the adoption of a conciliatory attitude an immediate conflict has indeed been avoided, but no one dares prophesy that permanent peace is secured. Many unionists are discontented, and since there is no power to enforce their acceptance of the findings of the Conciliation Boards, they are likely enough to repudiate them. The very fact that the Boards make unionists and non-unionists equal in power is sufficient to stir the former up to mischievous activity.

ANOTHER ship of the improved Dreadnought class is now in the water, the Superb having been launched from the building slip at Elswick on the seventh of the month. She presumably does not differ materially from the Bellerophon, launched on July 27th, and the Temeraire, now under construction at Devonport, but she will be more powerful than the prototype. It is also to be hoped that she will display better manœuvring qualities than the Dreadnought, which, as we have shown, is rather weak in this particular. She turns freely enough indeed, the peculiar position of the twin rudders immediately behind the after propellers giving her a great advantage in this direction; but although her four propellers reverse, they do not appear to take as good a grip of the water as could be desired, and it is very difficult to bring her up quickly. She has, by the way, been carrying out tests during the month with a new set of screws, but there was no marked improvement over the previous set. The Superb is to do 21 knots, and presumably Armstrongs will be allowed to design their own propellers. If they could see their way to machine them better results and reduced vibration might be possibly secured.

THE Hero, an ancient battleship, was subjected to bombardment by modern guns on Friday last. The objects of the experiment were not, as in the case of the Belleisle, which was attacked in 1900, to arrive at the general effect of gun fire on modern armour and *personnel*, but to discover, if possible, how long the electrical appliances fitted in connection with fire-control stations, with which all recent ships have been supplied, are likely to last in action. This was the main object of the test, but various other points were incidentally investigated. Great care has been exercised to keep the results secret, and the reports which have appeared in various places must be received with caution. It may, however, be noted that the reports speak unfavourably of the electrical connections, which are said to have failed after a very few discharges. If this is so the trials will be fully justified, as the lessons they enforce will be employed to effect improvements.

THAT part of the German Navy Act of 1900 which provides for the building of ships up to 1917, and determines the life of battleships and cruisers, is to undergo a radical change. The draft of a new clause, intended to replace the paragraph of the Naval Act in question, has already been sanctioned by the Bundesrat (Council of the Empire), and will, no doubt, receive the ratification of the Reichstag. The essence of the new Bill is the reduction of the maximum life of all armoured ships from twenty-five to twenty years, counting from the date on which the first instalment was voted to that on which the first credit for the construction of the "substitute" ship is endorsed. This apparently insignificant decision as to the life of warships involves many changes in the building programme, which during the period 1908-1917 will be as follows:—Three battleships to be built each year in 1908, 1909, 1910; two battleships to be built in 1911; one battleship each year from 1912 to 1917; one armoured cruiser each year from 1912 to 1917; two scouting cruisers each year from 1908 to 1916; one scouting cruiser in 1917. Hence at the end of 1917 the aggregate of new constructions will be:—Battleships built after 1907, 17; armoured cruisers, 6; ships of the line, 23; scouting cruisers, 19.

ADMIRAL GALSTER'S booklet, "What Sea Armament does Germany Need?" represents an almost unprecedented attack upon the German Admiralty's policy, and it is believed that it will greatly contribute to the adoption of a final scheme of submarine boat construction. Admiral Galster repeats and strongly advocates the French theories of the young school—modified, of course, and adapted to German geographical and political needs—and concludes by proposing the immediate construction of sixty diving boats, thirty 200 ton submarines for defensive purposes, whose object is to prevent a blockade of the North Sea and the Western Baltic, and thirty for offensive purposes, and intended to operate in the enemy's territorial waters. Needless to say, the hypothetical enemy on which Admiral Galster's arguments are based is Great Britain, and it is, he urges, only in "flotilla" warfare that German forces may meet the English fleet with any hope of success. It is hardly probable that such a scheme as this proposed *Kleinkrieg*, in open contradiction to Admiralty theories, can be realised in the near future. But the fact is remarkable that the submarine question, which in Germany has always been avoided, is now approaching a definite solution. This is proved by the consideration which is given in this year's navy estimates to underwater craft. Whilst in 1905 only £73,500 had been asked and granted for experiments with submarines, £123,000 were voted for 1906 and £147,000 for 1907; the estimates for 1908 propose, under the same head, £490,000, and £735,000 for the following year. The new submarine design will, of course, be based on the experimental work done by U1, which has undergone, and is still undergoing, an exhaustive series of successful trials.

A SUCCESSFUL contractors' trial trip has been carried out by the Thornycroft destroyer Tartar on the Stokes Bay Admiralty Course. This vessel is one of a new class of 33-knot turbine destroyers recently completed for the British Navy. She is 270ft. on the water-line in length, 26ft. in width, and 17ft. 2in. in depth, and is engined with turbines constructed by her builders. These are arranged on three shafts, and are capable of developing collectively some 14,000 horse-power. The high-pressure turbine on the centre shaft exhausts into the low-pressure turbines on the wing shafts. Forward of the low-pressure turbines are a high-pressure and a low-pressure turbine, each driving a shaft with one propeller. Steam is supplied by six water-tube boilers, fired with oil fuel, and working at a pressure of 220 lb. per square inch. The speed obtained on this trial was 33·122 knots, but it is fully expected that at the Admiralty trial, which may have taken place by the time these lines are in print, a higher speed than this may be recorded. The Mohawk, another of the 33-knot destroyers, built by Samuel White and Co., Limited, of East Cowes, actually made a mean speed, over six runs on the Maplins, of 34·511 knots. Her engines were then making 757·3 revolutions per minute. On a six hours' run, with mean revolutions of 751·4 to the minute, she is calculated to have averaged 34·245 knots. This is practically a knot and a-quarter over the contract speed. Her total oil-fuel consumption during the six hours' run was 68¼ tons. This vessel, like the Tartar, is 270ft. long, but she only has a beam of 25ft. Her machinery consists of Parsons type turbines, and her boilers are of the White-Forster type, adapted for burning oil fuel on the Admiralty system. There are three propeller shafts.

REPRESENTATIVE German opinion has recently paid a warm tribute to American electric railway engineering. The Government Commission of German electrical engineers which had been appointed to investigate American electric traction methods returned in the middle of November, after a three months' tour in the States and Mexico. The Commission was led by Privy Councillor Wittfeld, Director of Works and adviser to the German Government on the Electrification of Railways, and was accompanied by Professor Walter Reichel, Doctor of Engineering, of the Technische Hochschule at Charlottenburg, and Messrs. Frischmuth, Pforr and Jordan, representatives of the well-known firms of Siemens and Schuckert, the A. E. G., and Felten-Lahmeyer respectively. Privy Councillor Wittfeld is reported to have said that since he last studied the question in America the progress there in developing fast electric railways has been astonishing. He took special interest in the fact that the Americans are now almost exclusively adopting the single-phase system, which is also being used on the Blankenese-Ohlsdorf line near Hamburg, continuous current being less and less employed. The high standard of the work being done merited warm admiration, and it was surprising to see how, even wi scanty means, excellent results were accomplished. Herr Wittfeld further stated that the Commission had everywhere been most cordially received. Besides the numerous other plants inspected, no less than fifty-seven steam turbine-driven railway power stations had been visited. The tour has resulted in the collection of a copious mass of data which will be consulted when electrifying the Prussian railways. The American experience which had been placed at the disposal of the Commission will make it possible to adopt from the beginning the most suitable organisation of traffic, and to choose the most suitable engines and plant. Privy Councillor Wittfeld will prepare an official report on the labours of the Commission, embodying the information obtained in America, which will be laid before the Minister of Railways, and he will subsequently elaborate a memorial on the electrification of the Berlin city and suburban lines for the Ministry of Finance. An Engineering Department is now being organised, by which the final plans for the latter lines are to be fixed.

ON the 13th ult. Aberdeen opened the first portion of its new sewerage system. This forms part of a comprehensive scheme which was sanctioned under the Aberdeen Corporation Sewerage Act of 1898-9. It has been under construction for some six years, and includes the making of a high level outfall sewer over three miles in length, part of which is taken under the river Dee, and part through the Hill of Nigg by tunnel. The outfall is 21ft. below high-water mark, and is situated in the bay of Nigg, a little to the south of the Girdleness Lighthouse. The undertaking has presented a good many engineering difficulties, particularly in the tunnelling and foreshore works. The latter consists of pipes covered with huge masses of concrete dovetailed into the rocks. Frequently the constructional works at this point were stopped by storms. The sewer was designed with a capacity of 82 million gallons a day, which is a quantity equal to some 6½ times the dry weather flow of a population of 270,000 at 45 gallons per day. Storm water in excess of this amount is to discharge direct into the rivers Dee and Don or their tributaries. The sewer is to discharge by gravitation. The total cost of this section of the scheme has been some £80,000.

ON the 15th of November an agreement between the German and Swedish Governments relating to a train ferry to ply between Sassnitz, in Prussia, and Trelleborg, in Sweden, was signed at the Foreign-office in Berlin. According to official reports it is hoped that this means of communication will be handed over for public service by the summer of 1909. The present scheme provides for the supply of two Prussian and two Swedish ferry-boats capable of steaming at a speed of sixteen nautical miles per hour. All the boats are to be built on the same general lines, and are to take heavy trains, including sleeping cars. The execution of this project will entail considerable expenditure, because, in addition to other difficulties which will have to be overcome, indemnities will have to be paid to certain existing steamship lines. The contract by which Sweden's share of the carriage of the mails from Sassnitz to Trelleborg has been entrusted to the steamship company in Malmö, for instance, only commenced last May. The annual Government subsidy due to this company amounts to about £15,000. Although the Malmö company does not wish to retard the realisation of the proposed scheme, it will naturally demand an indemnity for the loss sustained by the abolition of the steamer communication, which was instituted at considerable cost. The train ferry is to be used both for goods and passenger traffic. The probable costs of a ferryboat for passenger trains will be several millions of marks, whilst

the slower boats for goods traffic are estimated at about one million each.

Having completed their military reorganisation, the Swiss will now grapple with other problems, prominent among which is the exploitation of their available water-powers. A Bill dealing with the latter question will be brought up for discussion by the councillors of the Helvetic Confederacy this month. And there is no time to be lost, for the last of the trial runs on the experimental track connecting Oerlikon, Seebach, and Wettingen, which have established the fact that Swiss engineers would now be fully prepared to proceed at once with the electrification of the whole of the Swiss railways if only sufficient hydro-electric power were available, took place in the presence of a large number of guests on the 13th of November. The necessary power will, however, be lacking until the immense stores of energy bequeathed to Switzerland by Nature in the shape of waterfalls and elevated lakes have been made serviceable, and for the time being steam turbines will be used. The above-mentioned experimental track is a branch line of the Swiss national railways which, for some years past, had been placed at the disposal of the Maschinenfabrik Oerlikon for the purpose of solving the problem of the electrification of the Swiss railways. It may now safely be assumed that the solution has been found, and very shortly the experimental track will be opened for regular passenger and goods traffic. The 13th of November, *i.e.*, the day on which the final trial run took place, is regarded in Switzerland as the birthday of a national work of immense economic importance. The current used on the line in question is supplied at 15,000 volts. The trials were commenced with a periodicity of 50 per second, but 15 periods have been finally adopted. The type of electric locomotives evolved, which it has now been definitely decided to use for the regular train service, will be capable of covering all distances in schedule time, irrespective of the weight of the trains, this being, of course, a great improvement on the present steam locomotives. The building of the experimental plant and track from Seebach to Wettingen took place very gradually. But a complete single-phase railway system, in which the locomotives, motors, and the methods of the conducting the current to the trains are reported to be entirely original, has now been produced.

A curious law case came to a conclusion on the 7th ult. In 1899 S. Pearson and Son, Limited, contracted with the Dublin Corporation to build a sewer outfall, &c., at a cost of £94,000. On the completion of the work an additional sum of £36,374 was claimed in respect of extra expenses, mainly due to the pumping required to keep the works dry during construction. It was alleged that fraudulent misrepresentations had been made regarding the depth of an existing river wall. The case first came before the Chief Baron and a jury in 1905, when the jury were directed to find for the defendants. The plaintiffs appealed, and when the case came before a Divisional Court the appeal was allowed. The Corporation then appealed, and the case came in June, 1906, before the Court of Appeal in Ireland, which reversed the decision of the Divisional Court. Messrs. Pearson then again appealed, and the decision of the Court of Appeal was reversed and the case sent for a new trial. Up to this time, therefore, the case had gone through four courts, and both sides had judgment given in their favour twice. Apparently they were then both tired of fighting, for the case was settled in the fifth court. The plaintiffs agreed to accept £5000 and to withdraw all imputation of fraudulent misrepresentation.

It would seem that the motor car "boom" has reached—if it has not already passed—its high-water mark. Judging from the reports of many of the large manufacturers, the trade done at the recent Show at Olympia showed a considerable falling off compared with the sales at last year's exhibition, and some firms are beginning to ask if the expenses attending such gorgeous displays are commensurate with the results. Although there were crowds of visitors, the percentage of purchasers did not come up to expectations. It seems practically assured that if another show is held next year its duration will be reduced by quite a-half. There are not wanting signs that, in the pleasure side of the industry at least, the production of cars is now in excess of the demand. Several British and Continental firms overshot the mark this year, and the purchasing public seem to be holding on till the inevitable reduction of prices takes place. Notwithstanding this tendency, some firms have indiscreetly enlarged their works to an extent which is totally unjustifiable, and large dividends have been paid, a large proportion of which would have been better applied if added to reserve funds.

The story told recently before the Canals and Waterways Commission by Mr. J. K. Blythell, the chairman of the Manchester Ship Canal Company, concerning the progress made by this great waterway, makes interesting reading. In the late seventies and early eighties trade in Manchester and the surrounding district was in a very depressed state. When the canal was promoted reductions in the rates of carrying goods between Liverpool and Manchester were made by the railway companies, and Liverpool reduced its port charges. These facts notwithstanding, the progress made by the undertaking has been steady, and if the results from the shareholders' point of view have not assumed tangible form, the effect of the cheapening of the carriage of imports and exports has been undeniably satisfactory to the great industrial district which the canal serves. The canal has inland communication with practically all the other canals in England. Some idea of its importance will be gathered from the fact that the total weight of imported articles last year was 2,489,000 tons and the total exports 1,951,326 tons. It is interesting to note that although the railway companies were the most strenuous opponents of the canal scheme, yet in the last twelve years the railway traffic between Liverpool and Manchester has almost doubled.

At its meeting on the 22nd ult., the Metropolitan Water Board considered a report which has been presented to it by its Works and Stores Committee. We have already dealt at some length with the proposals outlined in the report, but it will be well to put on record their general import. It is suggested that up to 1960, or thereabouts, London will most economically and efficiently increase its supply of water by retaining and developing its present sources. The Lee Valley will not provide much more water than it does at present. About 24 million gallons a day additional is all that can be expected. With the Thames the matter is very different. By the gradual creation of additional storage capacity, the Committee anticipate that a daily amount up to 450 million gallons may be obtained from the Thames alone, the present quantity being about 129 million gallons a day. It is hoped that as the population increases the amount of extra money received in rates will be sufficient to enable the additional works to be paid for out of revenue. By 1960 it is estimated that the population in the water area will amount to 16,286,000 persons. Before that time it will have been necessary to seek a supplemental supply of water, and it is urged that a gathering ground in Wales should be obtained without delay. It would not be necessary to construct waterworks on it at present, but it is urged that it should be purchased at once, and before it is appropriated by any other town.

While Mr. Lloyd-George is formulating his proposals for the betterment of the Port of London the dock companies also intend to deposit a private Bill next session which, judging from the official notice published, will be generally on the lines of that promoted and ultimately withdrawn last session. The companies propose that the Thames Conservancy shall be endowed with larger powers, and become the Port Authority. The Conservancy would be empowered to impose rates on goods imported, other than goods transhipped for conveyance to a foreign port, and certain other exceptions. A portion of these rates would be retained by the Conservancy for its general purposes, the balance being divided among the dock companies. The Bill also makes provision for levying tolls on barges and lighters using the docks and for their registration, and imposes upon the dock companies certain obligations with respect to the improvement of their properties and the construction of new docks. The promoters state that they intend to provide an alternative scheme should the Government's proposals fail by any mischance, and their measure will differ in some respects from that promoted by the companies last year, several details in the earlier Bill, to which exception was taken, having been amended.

Early in the month a fatal winding accident occurred at the Colet pit of the Cockerill Colliery, Seraing, Belgium. Happily, such accidents are at continental collieries of far less frequent occurrence than formerly. In Germany accurate records have been kept since 1872 in the Dortmund coal mining district, and they show that during the period of thirty-four years, of the 9207 winding ropes discarded 3·18 per cent. broke suddenly in use. In 1872 the fractures were 19·32 per cent., whilst in 1905 they were only 1·52 per cent. In Great Britain it is gratifying to note from the official mineral statistics which have recently been issued that in 1905, and again in 1906, there was not a single fatality from the breakage of winding ropes. The somewhat belated statistics referred to contain much information of great interest. They show that the British output of coal last year, over 250 million tons, was the highest hitherto recorded. Statistics of coke production show that over 19 million tons were made during the year. Another interesting fact brought to light is the continually increasing application of coal-cutting machinery in British collieries. In 1906, at 333 collieries, there were 1136 machines, the total quantity of coal obtained by their aid having been 10,202,506 tons, an increase of 2,100,309 tons compared with 1905 and of 4,458,462 tons compared with 1904. Similar increases in the use of coal-cutting machines also occurred in the United States, where 35·1 per cent. of the output is machine-mined, the number of machines having increased from 7663 in 1904 to 10,212 in 1906. An interesting event during the month was the celebration of the jubilee of the South Wales Institute of Engineers, a society that has done much towards the development of coal mining in South Wales. One of the past-presidents was Mr. T. Forster Brown, whose death was recorded in our columns on November 1st. The coal mining industry suffered another serious loss in the death of Mr. M. Walton Brown, the energetic secretary of the Institution of Mining Engineers, and one of the leading authorities on colliery ventilation.

The new reservoir in Charnwood Forest of the Corporation of Loughborough overflowed through the waste weir arches for the first time on the 25th ult., as a result of a heavy snowstorm. This reservoir has a capacity of 500 million gallons, and no traces have been found of the water leaking through or past the masonry of which it is composed. An unusual course was taken with this dam while it was being erected. In order to relieve the scarcity of water in the town when the dam was only 42ft. 6in. high, the water of the brook was temporarily stored to a height of 40ft., and a supply taken from the water so impounded. Meanwhile, the work of constructing the dam was still carried on. This dam is claimed to be the cheapest which has yet been made, the undertaking having cost only a little over £100,000. Another reservoir was formally opened on the 9th ult. This forms part of the waterworks for serving the Kilbirnie and Glengarnock district of Ayrshire. It is situated at an elevation of 800ft. above sea level, has a water area of 10 acres, and a greatest depth of 45ft. It has a capacity of 56 million gallons, and cost something over £14,500. With an existing reservoir the total storage is 66 million gallons, and the filter beds which have also been constructed are capable of delivering 1,700,000 gallons in twenty-four hours.

Owing to the bankruptcy of the Vienna General Omnibus Company the city authorities are again considering the construction of tramway lines through the crowded centre of the city. Hitherto, with unimportant exceptions, the "inner city," or the district encircled by the Ringstrasse, has been entirely free from tram lines, the public traffic being served by the omnibuses running to and from the Cathedral square in the centre of the city. For the most part the streets there are too crowded, as well as none too wide, for the running of tramcars. But with the probable cessation of the omnibus service something will have to be done to provide means of transport in this district, and it is now very likely that at least two tramway routes will be laid through the middle of the city. There is some talk of building a subway line, but that would be much too expensive an undertaking, for the present at any rate. The omnibus company endeavoured to persuade the municipality to take over the service, but the City Council declined. The Vienna General Omnibus Company is a British corporation, organised in 1881 with a capital of about £100,000. For some years the undertaking was fairly profitable—sometimes paying as much as 10 or 11 per cent., but the competition of the municipal tramways, especially after the introduction of the electric system, proved too much for the omnibus company, whose affairs became worse and worse, and last year the company lost heavily.

The new Croton dam of the New York Waterworks, which was fully described in our issues of the 12th, 19th, and 26th April, and 3rd and 10th May last, overflowed for the first time on the 6th ult. This dam holds up the enormous quantity of 38 thousand million gallons, and impounds the water that overflows from ten other dams in the Croton Valley above it. The lake it forms is nearly 20 miles long. For some time past it has been supplying to New York 314 million gallonsa day. It will be remembered that this dam was begun in 1892, and was not officially completed till January, 1906. Its design and construction were so recently described by us that it will not be necessary to refer to them again here. We understand that no important percolations of water through the masonry have been observed. There is, however, a slight seepage, though it is only in dark or cloudy weather that moisture can be observed on the down stream face. It has been noticed that this maintains a distance of about 30ft. below the water-level, wherever this may be. A careful examination below the dam has failed, so it is said, to show as yet the appearance of any spring or evidences of leakage through and around its foundations.

MR. LLOYD-GEORGE has redeemed his promise to deal with the Port of London Problem in the forthcoming session of Parliament; or rather, to be exact, he has given official notice of the intention of the Board of Trade to promote a Bill having for its object the constitution of a Port Commission for London. This Commission will supersede the Thames Conservancy and the Watermen's Company in relation to the river below Teddington. The new body will be partly elective and partly nominative, and is to contain representatives of Government departments, local authorities, and other interested parties. The income of the Commission is to be provided mainly by the imposition of increased dues on shipping and goods. The purchase of the existing docks, or any of them, may be effected by the Commission, and they may also construct docks and wharves of their own or assist other parties in the provision of additional facilities. The Port Authority is to be empowered to issue Port Stock which the London County Council may be required to guarantee. Funds for the further dredging of the river are to be raised by the County Council and City of London, or either of them. It is impossible to judge, until the Bill itself is issued, how far Mr. Lloyd-George proposes to identify the London County Council with the new Authority. At all events, some degree of municipal control is inevitable if the Port Authority is to have the assistance of municipal rate guarantee. There are numerous other provisions indicated in the notice, some of which were discussed in our last issue. While it is inevitable that the Bill will excite considerable opposition in Parliament, the terms of the notice foreshadow a measure which, if passed with adequate safeguards of existing interests, should be of lasting benefit to the interests of the Port of London. There is every reason to think that Mr. Lloyd-George's proposals are likely to meet with better success than have attended any former attempts to legislate for the improvement of the Port on a broad basis. The attitude of the present County Council and the almost universal desire of the many interests concerned to have the problem solved in one way or another without further delay are alike factors favourable to the passage of the Bill.

DURING the last week of October the new bow for the South Australian liner Suevic was successfully towed from Messrs. Harland and Wolff's shipbuilding yard at Belfast to Southampton, where it is now being joined to the other part of the ship. Considering the nature of the work and the difficulties to be encountered, the work has proceeded rapidly, and the makers should feel gratified to think that their difficult task has been carried out with such success. Great care is being taken with the work of joining the two parts together, and we were told that the renewed vessel will actually be stronger than she was at first. The two ends have been fitted together, and the vessel is now being built up in such a way that the whole structure from the keel up, including the plates in the shell, the whole of the decks, the double bottom, and also the keelsons, will occupy exactly the same positions as before, and all the structural arrangements will be as they were originally. Extra riveting is being resorted to so as to give an additional margin of strength. Special arrangements were made for getting the new structure into the exact position with regard to the aft portion of the dry dock. The bow was floated into position, and brought to rest at the required distance to make up the total length of the vessel, large baulks of timber being used as distance pieces. The work will now soon be finished, and early in the new year the repaired ship will re-enter the White Star Line's Australian service.

IN our last issue we made brief mention of an accident which happened during the lowering of a caisson necessary for the widening operations of Blackfriars Bridge. Unfortunately the results were even more serious than we had, at the time of going to press last week, reason to believe, for four men lost their lives. It appears that the operation of lowering the caisson had been commenced at about 7.30 a.m. on Thursday, the 28th ult. By 4.0 p.m. it had been lowered some 16ft. or 17ft., and its lower or cutting edge was just touching the surface of the river, the tide in which was flowing. Tackles were attached to the caisson and led backwards and forwards to the staging, and this regulated its position as it was being lowered. There were four points of support on four girders, and the weight carried at each point was 59 tons. The four cross girders were placed on the top of the staging. Three of the girders gave way and the fourth remained lying on its side across the top of the trestle. All the tackle and plant had, by the orders of the contractors—Messrs. Arrol and Co.—been carefully inspected before being employed, and found to be in good order; nevertheless, for some reason or other the caisson fell. As an inquest on the four men who were killed, and a Board of Trade inquiry both stand adjourned, we refrain at the moment from giving any further details and from making any comments on the accident.

RIFLED ARTILLERY.

By A. G. GREENHILL.

No. III.*

THE extension of Green's solution to a rotation of the ellipsoid discussed in my last article was made by Clebsch, by taking a velocity function $\phi = x\,y\,\psi$, where ψ is a function of λ only; and then as before, in the direction of the normal

$$(44)\quad -\frac{d\phi}{ds} = \left(\frac{dx}{ds}\,y + x\,\frac{dy}{ds}\right)\psi - x\,y\,\frac{d\psi}{ds}$$
$$= -(l\,y + m\,x)\,\psi - 2\,p\,x\,y\,\frac{d\psi}{d\lambda}$$
$$= -p\,x\,y\left[\left(\frac{1}{a^2+\lambda} + \frac{1}{b^2+\lambda}\right)\psi + 2\,\frac{d\psi}{d\lambda}\right].$$

But the normal velocity of the ellipsoid λ due to a rotation r about Oz is

$$(45)\quad r\,(m\,x - l\,y) = r\,p\,x\,y\left(\frac{1}{b^2+\lambda} - \frac{1}{a^2+\lambda}\right),$$

so that an ellipsoidal surface may rotate as a thin rigid sheet without disturbing the motion of the liquid, if the angular velocity

$$(46)\quad r = -\frac{\left(\frac{1}{a^2+\lambda} + \frac{1}{b^2+\lambda}\right)\psi + 2\,\frac{d\psi}{d\lambda}}{\frac{1}{b^2+\lambda} - \frac{1}{a^2+\lambda}}$$
$$= -\frac{(a^2+\lambda+b^2+\lambda)\,\psi + 2\,(a^2+\lambda)\,(b^2+\lambda)\,\frac{d\psi}{d\lambda}}{a^2-b^2}.$$

Continuity is secured by a consideration of the liquid between two ellipsoids λ and λ_1, and the plane $x = 0$ and $y = 0$. A similar procedure to that given above, omitted for brevity, will show that the condition is

$$(47)\quad (a^2+\lambda)^{\frac{3}{2}}\,(b^2+\lambda)^{\frac{3}{2}}\,(c^2+\lambda)^{\frac{1}{2}}\,\frac{d\psi}{d\lambda} = \text{constant},$$

$$(48)\quad \psi = \int_\lambda^\infty \frac{N\,d\lambda}{(a^2+\lambda)(b^2+\lambda)\sqrt{(4\,.\,a^2+\lambda\,.\,b^2+\lambda\,.\,c^2+\lambda)}}$$
$$= \frac{N}{a\,b\,c}\,\frac{B_\lambda - A_\lambda}{a^2-b^2},$$

where N is a constant, the quiescent ellipsoid being at infinity by taking $\lambda_1 = \infty$; and thence it will be found that the effective radius of gyration k' of the liquid is given by

$$(49)\quad k'^2 = \frac{\frac{1}{5}(a^2-b^2)^2\,(B_0 - A_0)}{a^2 - b^2 - (a^2+b^2)\,(B_0 - A_0)};$$

the proof is given in any treatise on Hydrodynamics. Although k' may be ignored in the artillery problem of the stability of a shot in the air, it is required in the motion of a submarine boat or an air ship, where the weight W and buoyancy W′ are equal, or nearly so.

The shape we have to deal with in practice is one of revolution; the egg-shaped bullet employed by Benjamin Robins can be obtained from the ellipsoid by putting $b = c$; so that we have to calculate

$$(50)\quad A = \int_0^\infty \frac{a\,b^2\,d\lambda}{2\,(a^2+\lambda)^{\frac{3}{2}}\,(b^2+\lambda)},$$
$$B = \int_0^\infty \frac{a\,b^2\,d\lambda}{2\,(a^2+\lambda)^{\frac{1}{2}}\,(b^2+\lambda)^2},$$

and we find

$$(51)\quad A = \frac{a\,b^2}{(a^2-b^2)^{\frac{3}{2}}}\,\text{ch}^{-1}\frac{a}{b} - \frac{b^2}{a^2-b^2},$$
$$B = \frac{-\,a\,b^2}{2\,(a^2-b^2)^{\frac{3}{2}}}\,\text{ch}^{-1}\frac{a}{b} + \frac{a^2}{2\,(a^2-b^2)},$$
$$A + 2\,B = 1,\quad \frac{r^2}{b^2}\,A + 2\,B = \frac{a}{\sqrt{(a^2-b^2)}}\,\text{ch}^{-1}\frac{a}{b}.$$

The length of the shot being denoted by l, and the calibre by d, and the length in calibres by x,

$$(52)\quad \frac{l}{d} = \frac{2a}{2b} = x,\ \text{and}\ y = x^2\,A + 2\,B$$
$$= \frac{x}{\sqrt{(x^2-1)}}\,\text{ch}^{-1}\,x = \frac{x}{\sqrt{(x^2-1)}}\,\text{sh}^{-1}\sqrt{(x^2-1)}$$
$$= \frac{x}{\sqrt{(x^2-1)}}\,\log_e\left[x + \sqrt{(x^2-1}\right],$$

and this has been calculated for the Table, and in conjunction with $A + 2\,B = 1$ it gives A and B, and thence

If σ denotes the density of the metal, and if the shell has a cavity homothetic with the external ellipsoidal shape, a fraction f of the linear scale, then the volume of a round shot being $\frac{1}{6}\pi\,d^3$, and $\frac{1}{6}\pi\,d^3\,x$, of the shell x calibres long,

$$(54)\quad W = \frac{1}{6}\pi\,d^3\,x\,(1-f^3)\,\sigma,\ W' = \frac{1}{6}\pi\,d^3\,x\,\rho,$$
$$k_1^2 = \frac{1}{10}\,d^2\,\frac{1-f^5}{1-f^3},\ k_2^2 = \frac{1}{20}\,(l^2 + d^2)\,\frac{1-f^5}{1-f^3}$$

so that

$$(55)\quad \frac{W'}{W} = \frac{1}{1-f^3}\,\frac{\rho}{\sigma},\ \frac{k_1^2}{d^2} = \frac{1}{10}\,\frac{1-f^5}{1-f^3},\ \frac{k_2^2}{k_1^2} = \frac{1}{2}\,(x^2+1),$$

$$(56)\quad \tan^2\delta = \frac{\pi^2}{n^2} = (\beta - \alpha)\,\frac{\rho}{\sigma}\,\frac{x^2+1}{\frac{1}{8}\,(1-f^5)},$$

the formula employed by Mr. A. G. Hadcock in the calculation of the Table, of which an extract follows, with a table of the rifling adopted by Krupp, for comparison with the value obtained by theoretical calculation.

Rifling adopted by Krupp.

Calibre in centimetres.	Length of common shell in calibres.	Pitch of rifling in calibres.	Calibre in centimetres.	Length of common shell in calibres.	Pitch of rifling in calibres.
30·5	2·75	45	17	—	59
28	2·5	50	15	3	45
26	2·5	50	15	2·5	68
26	2·6	50	15	3·5	25
24	2·5	70	15	4	25
24	2·75	45	15	2·5	65
24	4	25	15	2·5	50
21	2·5	68	12·5	2·75	40
21	2·9	45	12	2·5	60
21	2·5	59	10	3·8	25
21	4	25	8·7	2·6	40
17	2·6	45	8	2	46

The spiral helical nature of the path of the centre of the shot is noticeable near the muzzle before the shot has steadied down; it can be imitated experimentally by a toy screw propeller projected vertically in the the air, or by a falling leaf or disc which has received a spin, or a plate descending in water.

The baffling problem of drift is a similar gyroscopic effect, which causes the mean plane of the trajectory to be inclined from the vertical at a small angle of 2 to 3 deg.; but as drift is a side issue of curvature by gravity of the mean track, and no formula has been devised yet to suit the facts, derived on theoretical principles from the physical data, we leave the subject here a challenge to the ingenuity of the scientific artillerist.

In the steady motion in a medium under no force the centre describes a helix, such that the component velocity in the direction of the axis of the helix is

$$(57)\quad u\cos\theta + v\sin\theta = \left(1 + \frac{c_1}{c_2}\tan^2\theta\right)u\cos\theta;$$

and the component velocity at right angles is

$$(58)\quad u\sin\theta - v\cos\theta = \left(1 - \frac{c_1}{c_2}\right)u\sin\theta;$$

and this is equal to $Z\,\mu$ in steady motion, if Z denotes the radius of the helix, and μ the angular velocity of steady precession, so that

$$(59)\quad Z = \left(1 - \frac{c_1}{c_2}\right)\frac{u}{\mu}\sin\theta.$$

Writing the quadratic equation (12) in the form

$$(60)\quad \left[\left(1 - \frac{c_1}{c_2}\right)\frac{u}{\mu\cos\theta} - \frac{C_1}{c_1\,d}\tan\delta\right]^2$$
$$- \left[\frac{C_1^2}{c_1^2\,d^2}\tan^2\delta - \left(1 - \frac{c_1}{c_2}\right)\frac{C_2}{c_1}\right] = 0,$$

$$(61)\quad Z = \left\{\frac{C_1}{c_1\,d}\tan\delta + \sqrt{\left[\frac{C_1^2}{c_1^2\,d^2}\tan^2\delta - \left(1 - \frac{c_1}{c_2}\right)\frac{C_2}{c_1}\right]}\right\}\sin\theta\cos\theta,$$

reducing in the limiting case on the verge of stability to

$$(62)\quad Z = \frac{C_1}{c_1\,d}\tan\delta\sin\theta\cos\theta;$$

Table of Rifling for Stability of a Projectile.

Length, in calibres.		Cast iron common shell, $f = \frac{2}{3}$, S.G. 7. 2.		Palliser shell. $f = \frac{1}{2}$, S.G. 8. 0.		Solid steel bullet, $f = 0$, S.G. 8. 0.		Solid lead bullet, $f = 0$, S.G. 10. 9.	
x.	$\beta - \alpha$.	n.	δ.	n.	δ.	n.	δ.	n.	δ.
			deg. min.		deg. min.		deg. min.		deg. min.
1·0	0·000	∞	0 00	∞	0 00	∞	0 00	∞	0 00
2·0	0·494	63·9	2 49	71·1	2 32	72·2	2 29	84·3	2 08
2·5	0·606	47·9	3 46	53·3	3 23	54·2	3 19	63·2	2 51
3·0	0·682	38·5	4 41	42·8	4 13	43·5	4 09	50·7	3 33
3·5	0·737	32·1	5 35	35·7	5 02	36·3	4 58	42·4	4 15
4·0	0·778	27·6	6 30	30·7	5 51	31·2	5 45	36·4	4 56
4·5	0·810	24·2	7 24	26·9	6 40	27·4	6 32	31·9	5 37
5·0	0·835	21·6	8 16	24·0	7 28	24·4	7 21	28·4	6 18
6·0	0·872	17·7	10 05	19·7	9 04	20·0	8 56	23·3	7 40
10·0	0·939	10·3	16 57	11·5	15 19	11·6	15 05	13·6	13 00
∞	1·000	0·0	90 00	0·0	90 00	0·0	90 00	0·0	90 00

$$(53)\quad \alpha = \frac{A}{1-A} = \frac{1-2\,B}{2\,B} = \frac{y-1}{x^2-y},$$
$$\beta = \frac{B}{1-B} = \frac{1-A}{1+A} = \frac{x^2-y}{y+x^2-2},$$
$$\beta - \alpha = \frac{(x^2-1)\,(3y-x^2-2)}{(x^2-y)\,(y+x^2-2)} = \frac{x^2-1}{x^2-y} - \frac{2\,(x^2-1)}{y+x^2-2}.$$

and for a shot in air, we may take

$$(63)\quad \frac{Z}{d} = \frac{k_1^2}{d^2}\tan\delta\sin\theta\cos\theta.$$

The time over one complete turn of the helix is $2\pi/\mu$ seconds, during which the axial advance is

$$(64)\quad X = \left(1 + \frac{c_1}{c_2}\tan^2\theta\right)\frac{2\pi u}{\mu}\cos\theta,$$

reducing by reason of (60) in the limiting stability of the

* No. II. appeared November 29th.

shot, with $\theta = 0$, to

$$(65)\quad X = \frac{2\pi u}{\mu}\cos\theta = 2\pi d \cot\delta\frac{C_2}{C_1} = 2 n d \frac{k_2^2}{k_1^2} = (\text{pitch of the rifling})\ (x^2+1).$$

Thus for three calibre shell, $x = 3$, the pitch of the spiral path is 10 times the pitch of rifling, say, 200ft. for the 6in. gun.

A rifled gun is able to fire an elongated projectile several times heavier than a round shot of the same calibre, provided the spin given by the rifling is enough to secure steady axial advance; and for the same resistance the retardation is inversely as the weight, so that the projectile ranges further and hits harder than the round shot. Thus the conversion of the 6·3in. 32-pounder smooth bore into a rifled gun enabled it to fire a 64 lb. shell a little over 2½ calibres long, so that an angle of rifling of about 4 deg. will serve, giving one turn in 45 calibres. Benjamin Robins was the first to point out the advantage of the elongated shot in his tract "Of the Nature and Advantage of Rifled Barrel Pieces," July, 1747; but full advantage of the principle has not yet been taken by artillerists, although Whitworth from his tract of 1747 :—"I shall therefore conclude this paper with predicting that whatever State shall thoroughly comprehend the nature and advantage of rifled barrel pieces, and having facilitated and compleated their construction, shall introduce into their armies their general use with a dexterity in the management of them, they will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms; and will perhaps fall but little short of the wonderful effects which histories relate to have been formerly produced by the first inventor of fire-arms."

THE APPLICATION OF HIGHLY SUPERHEATED STEAM TO LOCOMOTIVES.

By ROBERT GARBE, Privy Councillor, Prussian State Railways.

(Conclusion.)

EXPERIMENTAL AND WORKING RESULTS WITH HOT-STEAM LOCOMOTIVES.

FROM the large amount of accumulated experience obtained on trial trips and in ordinary working with hot-tives, extending over several months. From the results of ordinary working alone it is not, however, easy to form a correct opinion as to the actual economy in consumption, as in many cases both handling and maintenance of hot-steam locomotives leaves much to be desired. The much more favourable results obtained on trial trips are to be regarded as ideal maxima obtainable by the method, and that these are not realised in continuous working is to be attributed to the circumstance that the size of the trains and the running times are arranged to meet the conditions suited to the best and most economical working of the ordinary locomotives, and not those suited to the much higher capacity of superheat locomotives. Notwithstanding these drawbacks, the average saving of coal as derived from practical working with superheated steam is from 25 to 30 per cent. of the consumption of simple and 15 to 20 of compound engines using saturated steam.

Comparative Trials of Saturated Steam Locomotives and Locomotives with Superheaters.

No.	Name of Railway.	Compound locomotives. Class of locomotive.	Number.	Axle arrangement.	Cylinder × stroke / Diar. driving wheel	Weight, tons.	Heating surface, square metres.	Grate area, sq. metres.	Class of superheater.	Character of service.	Time of service.	Saving by Superheating. Coal, per cent.	Saving by Superheating. Water, per cent.	Authority.
		Hot Steam 2-cylinder against Saturated Steam 2-cylinder.												
1	Prussian State lines	Saturated steam locomotive	3	3/4 coupled. Tank engine (2–6–0)	480 × 630 / 1500	59·7	120·5	1·7	—	Two months' working Berlin suburban traffic	May and June, 1905	19·7	39·3	Garbe Dampflok der Gegenwart S. 415
		Hot steam locomotive	3	3/4 Tank engine (2–6–0)	540 × 630 / 1500	61·5	103·4 + 29·5	1·7	Smoke-box					
2	Prussian State lines	Saturated steam locomotive	1	5/5 Hagentank engine (0–10–0)	520 × 630 / 1200	71·2	137·5	2·37	—	Working results	—	25	39	Berliner Maschinenbau, A. G. vorm. L. Schwartzkopff, Berlin
		Hot steam locomotive	1	Tank engine 5/5 (0–10–0)	610 × 630 / 1350	73·6	131·6 + 31·7	2·25	Smoke-box					
3	Aussig-Teplitz Railway Company	Saturated steam locomotive	1	3/5 (4–6–0)	500 × 650 / 1650	60·4	175·5	2·9	—	Result of five months' work	1906	20·0	—	K. K. priv. Aussig-Teplitzer Eisenb. Gesellsch.
		Hot steam locomotive	1	3/5 (2–6–2)	540 × 630 / 1620	66	202·4 + 47·6	3·67	Fire-tube					
4	Swedish State lines	Saturated steam locomotive	2	2/4 (4–4–0)	420 × 559 / 1880	41·1	98	1·97	—	Several journeys	Sept. 1906	47·1	49·5	Teknisk Tidskrift, 2 März, 1907
		Hot steam locomotive	1	2/5 (4–4–2)	500 × 600 / 1880	59	134 + 32·5	2·7	Fire tube					
5	Bergslay Railway, Sweden	Saturated steam locomotive	3	2/4 (4–4–0)	432 × 610 / 1700	36	92·5	1·5	—	Working results	August to December, 1905	26·7	—	Die Lokomot, August, 1906, S. 146
		Hot steam locomotive	1	2/4 (4–4–0)	470 × 610 / 1700	39·4	90 + 17	1·65	Fire-tube					
6	Belgian State lines...	Saturated steam locomotive	—	3/5 (4–6–0)	520 × 660 / 1700	—	173·2	2·81	—	Numerous working trips	1905	27	24	Garbe Dampflok der Gegenwart. S. 424
		Hot steam locomotive	—	3/5 (4–6–0)	520 × 660 / 1700	70·2	145 + 33·1	2·84	Fire-tube					
7	Belgian State lines...	Saturated steam locomotive	—	3/3 (0–6–0)	470 × 660 / 1520	43·8	115·4	2·52	—	A series of working trips	April, 1906	32	28·5	Garbe Dampflok der Gegenwart S. 424
		Hot steam locomotive	—	3/3 (0–6–0)	500 × 660 / 1520	47·6	96·1 + 21·5	2·52	Fire-tube					
8	Northern Bohemian Railway Company	Saturated steam locomotive	—	2/4 (4–4–0)	425 × 500 / 1730	43·24	Wasserberührt 116·64	2·01	—	Continuous working between Prag and Turnau		25·4*	20	
		Hot steam locomotive	2	3/4 (2–6–0)	500 × 600 / 1522	47·8	108·3 + 25·6	2·35	Fire-tube					
		Hot Steam 2-cylinder against Wet Steam Compounds.												
9	Prussian State lines	Wet steam locomotive	1	2/5 (4–4–2)	2 (340 + 560) × 640 / 1980	63·7	179	2·59	—	212 miles working runs	1905	21·1	36·7	Garbe Dampflok der Gegenwart, S. 375
		Hot steam locomotive	1	2/4 (4–4–0)	540 × 600 / 1980	55·3	101·7 + 30·8	2·27	Smoke-box					
10	Canadian Pacific Railway	Wet steam locomotive	12	4/5 (2–8–0)	(559 + 889) × 711 / 1448	73·5	185	4·05	—	Four months' working	January to April, 1905	14·5	—	Master Mechanics' Association, 1905
		Hot steam locomotive	6	4/5 (2–8–0)	533 × 711 / 1448	84·4	199·1 + 34·8	4·05	Fire-tube					
11	Canadian Pacific Railway	Wet steam locomotive	41	4/5 (2–8–0)	(559 + 889) × 711 / 1448	73·5	185	4·05	—	Seven months' working	May to October, 1905	17·8	—	New York Railway Club, April, 1906
		Hot steam locomotive	20	4/5 (2–8–0)	533 × 711 / 1448	84·4	199·1 + 34·8	4·05	Fire-tube					

* The company further remark that, if the line, which has very variable gradients, had permitted the power of the engine to be better utilised, it is certain that the relative saving would have been larger.

(*b*) INCREASED WORKING CAPACITY OF THE HOT STEAM ENGINE.

In the first article of the series the above point having stated, fifty years ago, that a twist of one turn in 18 calibres is enough for all projectiles up to six calibres long, which agrees with the theoretical result of our Table.

Artillerists are still hovering timidly over four-calibre shell as the length which should not be exceeded, afraid to follow the bold lead given by Whitworth fifty years ago and more, in using six calibre proportions, and longer. The next few years will see a great change by the adoption of Whitworth's pioneering ideas, and this will necessitate a reconstruction of gun, projectile, and ballistic table as well, based on experiment with the new form.

We may wind up then with Robins, by a quotation

(*a*) SAVING OF COAL AND WATER WITH HOT-STEAM LOCOMOTIVES.

In the following table the results as regards the saving of fuel and water by locomotives with Schmidt superheaters computed from figures communicated by different railway authorities will be found. For the most parts the figures have been obtained by comparative trials under similar conditions of hot steam with ordinary locomo-

* No. VI. appeared November 29th.

been theoretically considered, it will only be necessary to illustrate it further by a series of examples of practical results. These are taken from the author's work on the "Modern Steam Locomotive."

In the illustrations Figs. 16—20 the working results of superheated steam locomotives on the Prussian and Belgian State lines are represented graphically. They are selected from such parts of trial trips as show most clearly the extraordinary working capabilities of the method. In Figs. 16, 17, 18, and 20 the times are shown as abscissæ, which departure from the usual practice gives a distorted outline to the section, but as the individual

THE USE OF SUPERHEATED STEAM IN LOCOMOTIVES

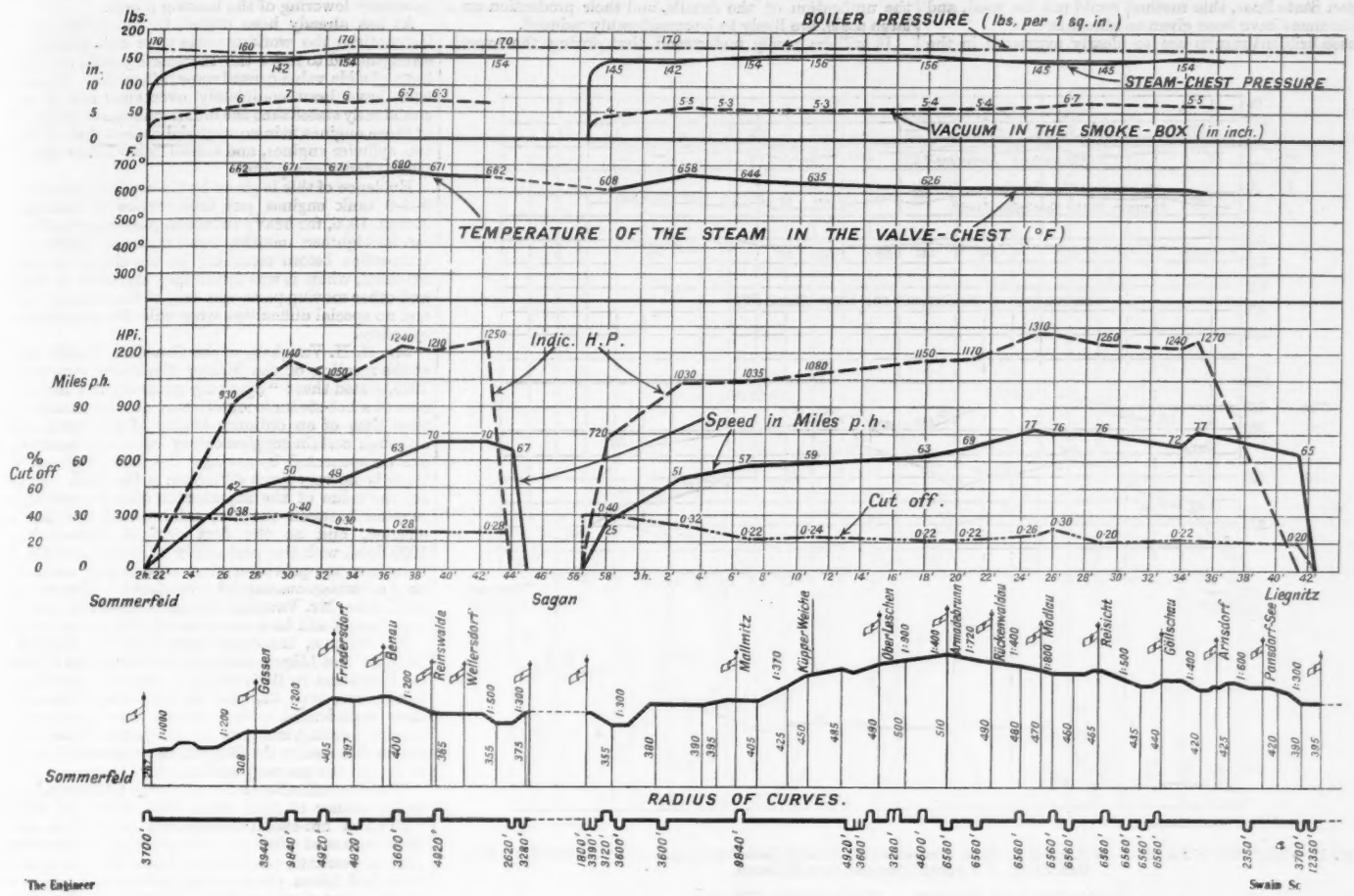


FIG. 16.—*Trial Run with a* (4—4—0) *Superheated Steam Locomotive with Schmidt Smoke-tube Superheater, on March 31st, 1906, from Sommerfeld to Liegnitz* (67 *Miles—Prussian State Railways*).

Weight of carriages, 301·6 tons. Weight of train, 406·4 tons.

Type of engine	4—4—0	Heating surface, fire-box	132·5 sq. ft.	Weight of engine in working order	56·7 tons
Superheater	Schmidt—smoke-tube	,, ,, tubes	1292·8 sq. ft.	Weight of tender in working order	78·1 tons
Diameter of cylinders	21·65in.	,, ,, superheater	341·2 sq. ft.	Coal	5 tons
Stroke	24·8in.	,, ,, total	1766·5 sq. ft.	Water	4730 Brit. gals.
Diameter of driving wheels	82·67in.	Grate area	24·2 sq. ft.		
Boiler pressure	170 lb. per sq. in.	Weight on driving-wheels	31·5 tons		

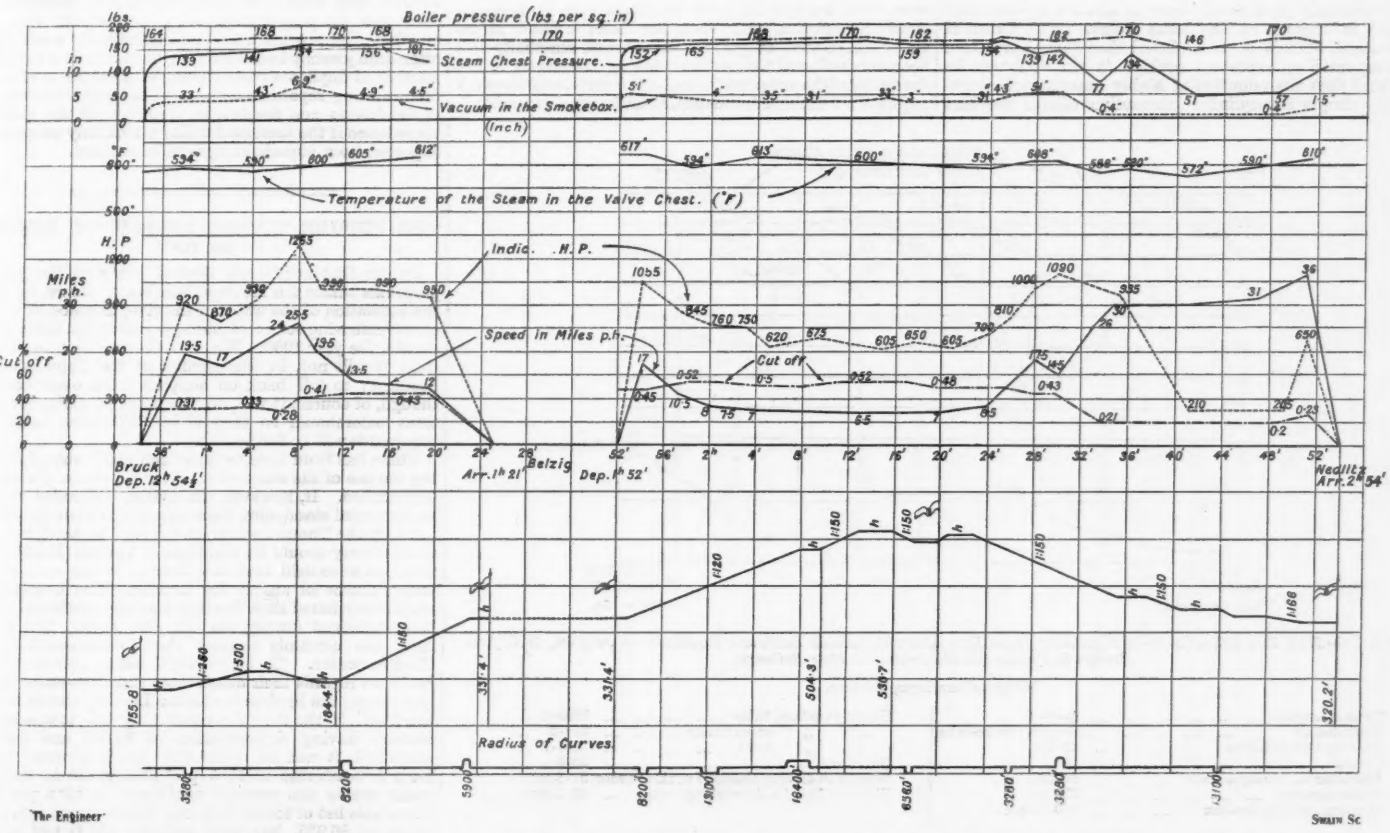

Boiler pressure (lbs per sq. in)
Steam Chest Pressure.
Vacuum in the Smokebox. (inch)
Temperature of the Steam in the Valve Chest. (°F)
Indic. H.P.
Speed in Miles p.h.
Cut off
Bruck Dep. 12h 54½'
Belzig Arr. 1h 21' Dep. 1h 52'
Nedlitz Arr. 2h 54'
Radius of Curves
The Engineer
Swain Sc

FIG. 17.—*Trial Run with a* (0—10—0) *Superheated Steam Tank Locomotive with Schmidt Smoke-box Superheater, on June 29th, 1905, from Brück to Nedlitz* (*Prussian State Railways*).

Weight of carriages, 1418·3 tons. Weight of train, 1490·7 tons.

Type of engine	0—10—0 tank locomotive	Boiler pressure	170 lb. per sq. in.	Grate area	24·2 sq. ft.
Superheater	Schmidt, smoke-box	Heating surface, fire-box	128·6 sq. ft.	Weight of engine in working order	72·4 tons
Diameter of cylinders	24in.	,, ,, tubes	1288·4 ,,	Coal	2 tons
Stroke	26in.	,, ,, superheater	341·2 ,,	Water	1540 Brit. gals.
Diameter of driving wheels	53·2in.	,, ,, total	1758·2 ,,		

gradients are given this will not be found to be an inconvenience, as the curve shows the work done, and especially the period of its duration simultaneously, so that the average duty can be easily deduced. In Fig. 19, referring to the Belgian State lines, this method could not be used, and the distances have been given as abscissæ.

These brilliant results are so clearly expressed in the figures that further explanations will be superfluous. Similar results have never been obtained with saturated steam in engines of the same weight and number of axles, and when it is remembered that they have been accompanied by important savings, it can no longer be doubted that the adoption of highly superheated steam in the simple two-cylinder locomotive affords the best means of increasing the power of the locomotive while retaining simplicity of construction.

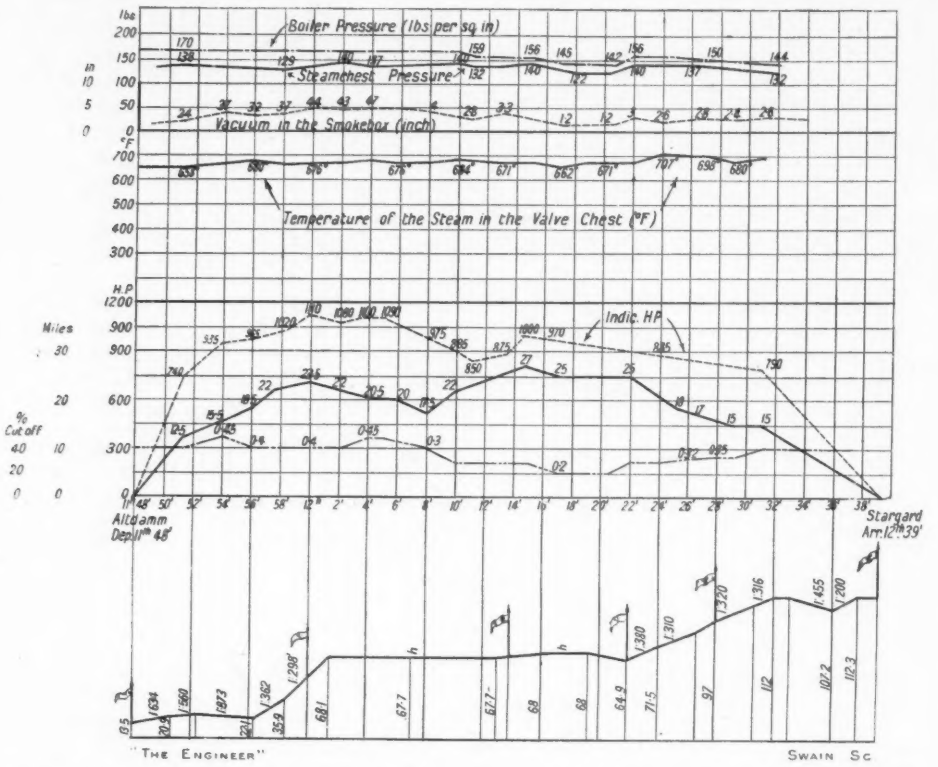

Boiler Pressure (lbs per sq in)
Steamchest Pressure
Vacuum in the Smokebox (inch)
Temperature of the Steam in the Valve Chest (°F)
Indic. H.P.
Altdamm Depar 8h 48'
Stargard Arr 12h 39'
"THE ENGINEER"
SWAIN Sc

FIG. 18.—*Trial Run with a* (0—8—0) *Superheated Steam Locomotive with Schmidt Smoke-box Superheater on January 13th, 1905, from Stettin to Stargard (Prussian State Railways).*

Weight of carriages, 1611 tons. Weight of train, 1709 tons.

Type of engine	0—8—0	Heating surface, superheater	341·2 sq. ft.
Superheater	Schmidt, smoke-box	,, ,, total	1764·8 ,,
Diameter of cylinders	23·2in.	Grate area	24·1 ,,
Stroke	26in.	Weight on driving wheels	55·1 tons
Diameter of driving wheels	53·2in.	,, of engine in working order	55·1 ,,
Boiler pressure	170 lb. per sq. in.	,, of tender in working order	42·3 ,,
Heating surface, fire-box	130·6 sq. ft.	Coal	5·6 ,,
,, ,, tubes	1293 ,,	Water	3520 Brit. gals.

(c) CONSTRUCTION AND MAINTENANCE COST.

Having thus demonstrated the undoubted advantages of the system, the objections made on the ground of greater costliness remain to be considered. The extra cost due to the superheater, and the increased size of some of the working parts, having regard to the necessary advantages already noticed, and the practical abolition of piloting, are comparatively small, and with the unification of the details, and their production on a large scale, are likely to be considerably reduced.

It will be easily understood that during the experimental period many mistakes were made. Every new form brought its own problems with it, and the experience gained with each has been utilised in its successor, so that at present the desired simplicity has been attained, and the accumulated experience as to the durability of the superheater and other parts, and the work required for their maintenance, is uniformly favourable.

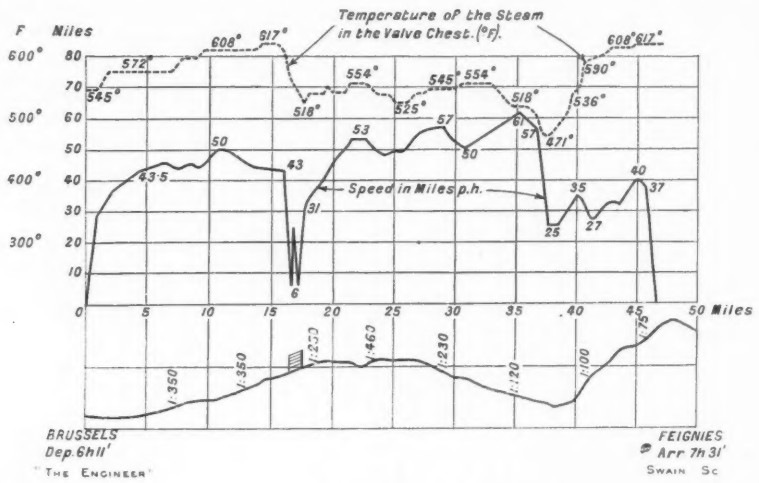


FIG. 19.—*Trial Run with a* (4—6—0) *Superheated Steam Locomotive with Schmidt Smoke-tube Superheater on July 6th, 1905, from Brussels to Feignies (50 Miles—Belgian State Railways).*

Weight of carriages, 350 tons.

Type of engine	4—6—0	Heating surface, tubes	1399·4 ,,
Superheater	Schmidt, smoke-tube	,, ,, superheater	356·3 ,,
Diameter of cylinders	20·5in.	,, ,, total	1916·7 ,,
Stroke	26in.	Grate area	30·6 ,,
Diameter of driving wheels	66·9in.	Weight on driving wheels in working order	51·8 tons
Boiler pressure	200 lb.	Weight of engine in working order	69·1 tons
Heating surface, fire-box	160·4 sq. ft.		

As regards the cost of maintenance, the experience with smoke tube superheaters on the Prussian State lines extends over too short a period to allow of a final estimate being formed, but their excellent behaviour in current work, together with the much larger experience of foreign railway companies, justifies the opinion that no difficulties are to be anticipated on this ground.

It is, however, essential that the regulations for tube cleaning shall be rigorously observed, as if this is not thoroughly done deposits accumulate in the tube, diminishing the free draught of the heating current, with a necessary lowering of the heating power.

As has already been stated, in the earlier hot-steam locomotives the working parts were not proportionately strengthened to meet the increased power, and the new form of slide valve caused some difficulties. These, however, have been completely overcome, and it may be confidently stated that the maintenance cost of the newest of these engines is in no way higher than that of the plain two-cylinder engines, and considerably below that of the four-cylinder compound.

Evidence of this is given by the working results of the 2-6-0 tank engines put into service in February and March, 1905, for heavy suburban passenger traffic, which ran for eighteen months, covering from 62,000 to 73,000 train-miles before returning to the shops for complete overhaul, when it was found that the wear of the axles and other moving parts was only of the ordinary amount, and no special difficulties arose with the superheater and cylinders.

Mr. H. H. Vaughan, of the Canadian Pacific Railway, at the meeting of the Master Mechanics' Association in 1905, stated that: "Speaking generally the maintenance cost of a hot-steam locomotive is not necessarily greater than that of an ordinary engine of the same size, for although certain supplementary costs are incurred, they are compensated by savings in other directions, so that there is no very great difference in the total. If this be so, the value of the superheater only depends upon the relation between the first extra outlay and the saving effected, and as the first cost at present is about 1000 dols., with the probability of a considerable future reduction, the provision of a superheater seems to be a very advantageous capital investment." Under American conditions, Mr. Vaughan considers that the cost of the superheater will be covered by the savings in two years.

M. Flamme, Inspector-General of the Belgian State lines, at the Liège meeting of the Institution of Mechanical Engineers in 1905, stated in regard to the hot-steam locomotive, type 35, that no particular difficulties had been experienced with it during one and a half year's regular working, and that in consequence of the uniformly favourable results the Belgian Government had decided to extend the use very considerably.

The Bohemian North Line Railway Company, in a letter to the author of April 20th, 1907, states as follows:—"The two hot-steam locomotives supplied in the year 1905 were sent after a year's working to the shops for general overhaul, when it was found that no appreciable wear had taken place in the pistons and slide valves, which, after cleaning, were replaced in the same condition. In the same way no defects were found in the superheating apparatus, and the total cost of the first overhaul was not higher than that of ordinary locomotives after doing the same amount of work." The experience of other lines leads to the same conclusion as that last stated.

Care, however, must be taken in the driving of hot-steam locomotives that the prescribed regulations be exactly and intelligently followed. It is, therefore, necessary that men shall not be put in charge of these engines until they have been thoroughly instructed in their use by properly qualified instructors; and the smallest deficiencies must be immediately made good after each journey in the running shed, where a sufficient number of duplicate parts should be provided to allow of defects being repaired at once. The proper instruction of the drivers and firemen is, however, of the greatest importance if the increased utility which may properly be expected from superheating is to be realised.

THE FUTURE WATER SUPPLY OF LONDON.

No. II.*

IN our first article we showed how that the present proposals before the Metropolitan Water Board included the utilisation of the water of the river Thames, by means of an increasing series of storage reservoirs, until, at all events, the year 1960. We also showed that until that time it will not, in the opinion of the Committee, be necessary to fall back on supplies from other sources, though, of course, it will be necessary to make preparations beforehand, so that if in 1960 more water be required it will be forthcoming.

There has from time to time been much outcry regarding the use of the water of the river because of its liability to pollution. If, however, the matter be looked at from an impartial standpoint, there appears to be every reason, not why the Thames water should not be used, but why it manifestly should be employed. Various Royal Commissions have held that the Thames is the natural and proper source of supply for London. The evidence on which they based their findings has been reinforced rather than weakened during the last few years. The actual facts are certainly against the abandonment of the Thames water. To begin with, hard-water towns are better as regards their death-rates than soft-water towns, and among the hard-water towns London stands well to the fore. If the statistics concerning the towns in this country having a population of 90,000 and over be examined, it will be found that the hard-water towns have a death-rate of 16·5 per 1000, while in the soft-water towns the average death-rate is 19·2 per 1000. From this list of towns Hornsey, which only has a population of 86,935, has been omitted, but it will be well to mention it, as it is within the area of the Water Board. The death-rate in this place is phenomenally low, being only 8·9 per 1000. This is the lowest death-rate anywhere in the country, and offers of itself very strong evidence of the excellence of the water supply of London. But, though it is so low there, there are

* No I. appeared November 29th.

THE USE OF SUPERHEATED STEAM IN LOCOMOTIVES

(For description see page 562)

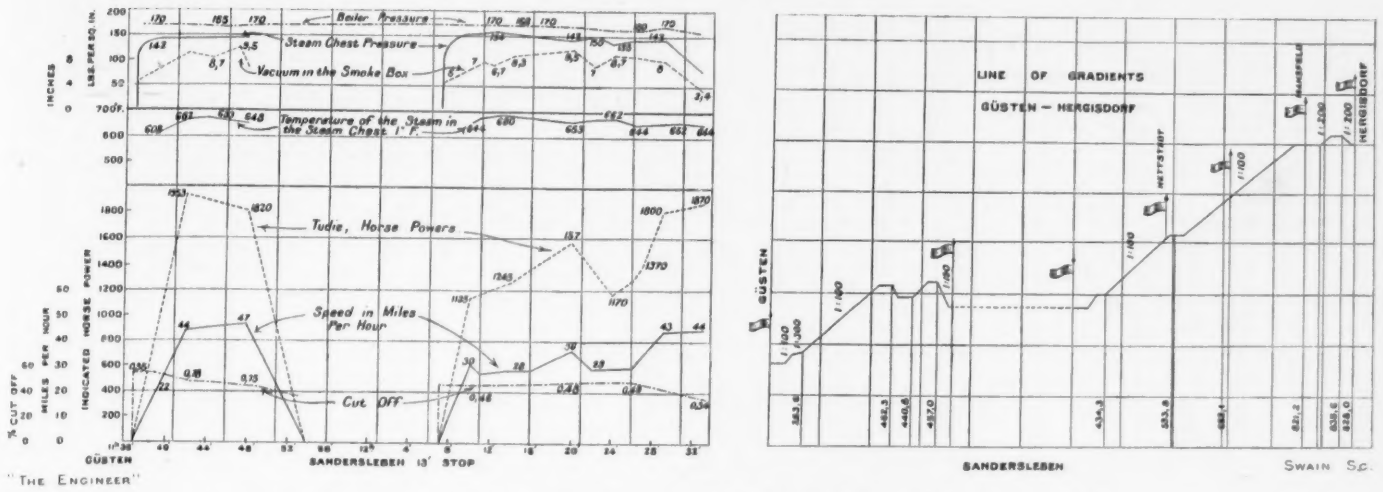


FIG. 20.—*Trial Run of a* (4—6—0) *Superb Steam Express Engine, between Güsten and Hergisdorf, on August 1st, 1906.*

Weight of 12 carriages, 394 tons. Gross weight of train, 512 tons.

Chief dimensions of engine—		Heating surface of superheater	531·7 sq. ft.	Weight on driving wheels	46·9 tons
Diameter and stroke of cylinders	23·2in. × 24·8in.	,, ,, total	2152·8 ,,	,, of engine	68·5 ,,
,, of driving wheels	68·9in.	Grate area	28·0 ,,	,, of tender	49·1 ,,
Heating surface of boiler	1621·1 sq. ft.	Boiler pressure	170 lb.		

districts in London which have a death-rate not very much in excess of it. Thus Leyton comes next with 12·2, and then come Walthamstow and Willesden close behind. Moreover, if the average of the whole of England and Wales be taken, the rate will be found to be 16·8 per 1000, so that London is actually in a better condition than the rest of the country.

Then again, as regards fever, the hard-water towns show a mean mortality of ·16 per 1000, whereas the mean for the soft-water towns is ·19. Greater London has a rate of ·12, and the County of London a rate of ·11. The metropolitan area, therefore, is less liable to diseases which are supposed to be connected with water than the whole of the rest of England. These figures deal with the ten years 1896-1905, but they are strikingly emphasised by the statistics regarding a week in the middle of last month. These showed that of the eleven lowest annual death-rates from all causes in the whole country, the Metropolitan area claimed no less than 6, Walthamstow having a rate of 7·8, Leyton and Tottenham both 8·5, and Willesden 9·1.

While on this subject we may well quote the finding of Lord Balfour's Commission, because it puts the question so clearly and emphasises just the very points on which stress should be laid. Paragraph 178 of the Commissioners' "Conclusions as to Quantity and Quality" is as follows:—

"We are strongly of opinion that the water, as supplied to the consumer in London, is of a very high standard of excellence and of purity, and that it is suitable in quality for all household purposes. We are well aware that a certain prejudice exists against the use of drinking water derived from the Thames and the Lee, because these rivers are liable to pollution, however perfect the subsequent purification either by natural or artificial means may be; but having regard to the experience of London during the last thirty years, and to the evidence given to us on the subject, we do not believe that any danger exists of the spread of disease by the use of this water, *provided that there is adequate storage, and that the water is efficiently filtered before delivery to consumers.*"

The italics are our own. It is just these two factors which make the difference between safety and danger. It will be noticed that fourteen years ago the Balfour Commission realised the advantage, as regards purity, of large storage. The knowledge on this question has largely increased in the meanwhile. It is now fully realised that for water to rest for a more or less long period in a reservoir is beneficial not only in that suspended matter is deposited, but also in that pathogenic germs are rapidly exterminated. This is a point on which great stress is laid by the Works and Stores Committee of the Board in commendation of their proposals. Let us in this connection consider for a moment the question of what proportion the suggested storage capacity will bear to daily supply. By 1960 it is proposed to have constructed storage reservoirs with a total capacity, inclusive of present storage, of, say, 54,000 million gallons. The daily demand at that time from the Thames as a source is estimated at 450 million gallons, so that for every gallon supplied there will be a storage of some 120 gallons. In other words, leaving out the question of evaporation, there would be 120 days' supply without drawing upon the Thames at all. It would be impossible to give a hard-and-fast rule for loss by evaporation in this country because the climate is so variable, so that an exact statement of how many days' supply would be available cannot be made. It would, however, probably be well within the mark to say that there would be enough for eighty days. In no possible drought that can be foreseen will the river be so low for eighty days that no water can be taken from it.

It will be seen, therefore, that the amount of storage proposed will be such that the water will make a lengthened stay in the reservoirs and become correspondingly purified. We have spoken hitherto only of the amount of storage which it is proposed to provide by the year 1960. It is not, of course, intended to construct all the necessary reservoirs at once, and the following table is interesting as showing the amount of storage which it is estimated will be required by the dates indicated, together with the average daily supply which it is anticipated can be derived from the Thames in those respective years:—

Date	Average daily supply from Thames.	Gross total storage required.*	Amount of such storage per one million gallon average daily supply.
	Million gallons.	Million gallons.	Million gallons.
1916	174·5	6,436	36·88
1921	196	9,886	50·44
1926	218·5	13,492	61·74
1931	244	17,534	71·86
1936	271·5	22,327	82·23
1941	300	27,276	90·92
1948	350	36,052	102·94
1954	400	44,862	112·15
1960	450	54,059	120·13

These figures may be put in another way as follows:—

Additional storage which would be required during the 5 years		Million gallons.
Do. do.	1916-1921 ...	3450
Do. do.	1921-1926 ...	3606
Do. do.	1926-1931 ...	4042
Do. do.	1931-1936 ...	4793
Do. do.	1936-1941 ...	4949
Do. do. 7 years	1941-1948 ...	8756
Do. do. 6 do.	1948-1954 ...	8830
Do. do. 6 do.	1954-1960 ...	9197

Beyond this point another factor comes into play. In making the foregoing calculations, various periods of drought have been taken into account, for it must be remembered that only when the river contains beyond a certain amount of water can any abstraction whatever be made. The period of drought on which the 1960 figures —450 million gallons a day—were based was that which occurred between May 6th, 1899, and November 3rd, 1899. When it comes to the taking of an extra 50 million gallons a day, as it is calculated would be necessary by 1965, a possible period of drought similar to that between 22nd May, 1901, and 28th November, 1902, has to be taken into account, and this would necessitate increasing the storage from 54,059 to 98,683 million gallons just to obtain this additional amount a day. Similarly, and for a like reason, to get a further 50,000 gallons a day the storage would have to be made 126,699 million gallons, and to provide 600 million gallons a day 157,044 million gallons of storage would be required. The capital cost of storage per million gallons for a supply of 450 million gallons a day is estimated at £55,170; for 500 million gallons, £267,810; for 550 million gallons, £168,030; and for 600 million gallons, £182,070.

Now, if we take the figures of Sir Benjamin Baker and Mr. G. F. Deacon, which were given in their report on Sir A. Binnie's Welsh scheme, the capital cost of a first instalment of 66⅔ million gallons average daily supply from the Wye sources would be £153,222 per million gallons. The capital cost of a second instalment of like amount would be £26,398 per million gallons, and for a third instalment of 66⅔ million gallons £28,872 per million gallons. Or, if the total average daily supply of 200 million gallons be considered, the capital cost would be £69,501 per million gallons.

It is perfectly easy to see, therefore, that the Committee are right in taking it that the economical limit in abstracting water from the Thames has been reached at 450 million gallons a day, for the cost would be greater than that necessary to go to Wales.

The method which it is proposed to adopt in order to obtain the necessary increased storage as and when it is required is of the simplest. It will not be necessary for us to go deeply into details concerning it, but we may say that it consists essentially in proceeding gradually and in increasing the reservoir capacity from period to period, always keeping the reserve beyond requirements. Hence it is anticipated that the works, as carried out, will be paid for out of revenue by reason of the extra amount received from the increased population. We may add that according to estimate the present and authorised equipment should be sufficient to cover requirements up to the year 1916. Before that time, however, further works will have to be undertaken so as to be prepared for increased demand later on.

We understand that it is anticipated that there will be no trouble in obtaining the necessary sites for reservoirs. Indeed, we gather that one locality has been carefully studied because it offers a particularly favourable position for the formation of a huge reservoir which can be constructed in progressive stages as and when the demand may arise, and at a particularly moderate cost. At the moment, however, we are precluded from saying more than this.

Naturally, with the construction of further reservoir capacity the filter area will have to be increased, and it is proposed to do this in the necessary proportion. Here it may be remarked that increased storage has a very favourable effect on the cost of filtration. Indeed, we understand that it costs rather less than half to filter water which has been in a reservoir for some time than it costs to filter rough river water. This can readily be appreciated when thought is given to the muddiness of unsettled water, especially if this be abstracted from a river like the Thames when it is in flood. The advantages gained by adequate subsidence prior to filtration are clearly shown by a comparison between the area of filter beds cleaned during a month in the summer of 1906, in the Chelsea and Southwark and Vauxhall divisions. Chelsea cleaned 6 acres during the month for a daily supply of 14,264,000 gallons, while Southwark and Vauxhall cleaned 73 acres for a supply of 41,104,000 gallons—a ratio of 4 to 1. However, the cost of filter beds is not such a serious item as might have been imagined. It appears, in fact, to be about one-seventh of that required for the construction of storage reservoirs.

A great deal more might be written on the subject of filtration. There is no doubt that it has now-a-days reached a very high state of efficiency. The water examiners' reports published monthly bear eloquent testimony to this. The Thames may be polluted, but, thanks to the Thames Conservancy, it is not nearly so polluted as it was. This, however, is not the point. What concerns the consumers is whether or not the water supplied is pure. Statistics show that it is. By no means the whole of the water coming down the Thames is due to rainfall flowing off the surface of the watershed. One authority has said that the river actually flows on the top of springs. This is literally the case. In the bed of the river there are the outflows of numberless springs having their sources in the Thames watershed. The water of these springs is purified by long periods of percolation through natural filtering materials, so that irrespective altogether of the rainfall there is continually coming down the river a large volume of pure water.

As time goes on, and as the works insisted on by the Thames Conservancy are completed, the amount of sewage in the river will be less and less, and the river become purer and purer. It may be said that the watershed, consisting largely of grazing land, impurities will continue to reach the river. This may be so, but their amount will, when all the sources of pollution from human sewage are removed, be practically negligible.

* Including storage in existence or authorised by Parliament and the Board, viz., 7279·5 million gallons.

A PORTABLE ENGINE WITH SUPERHEATER.

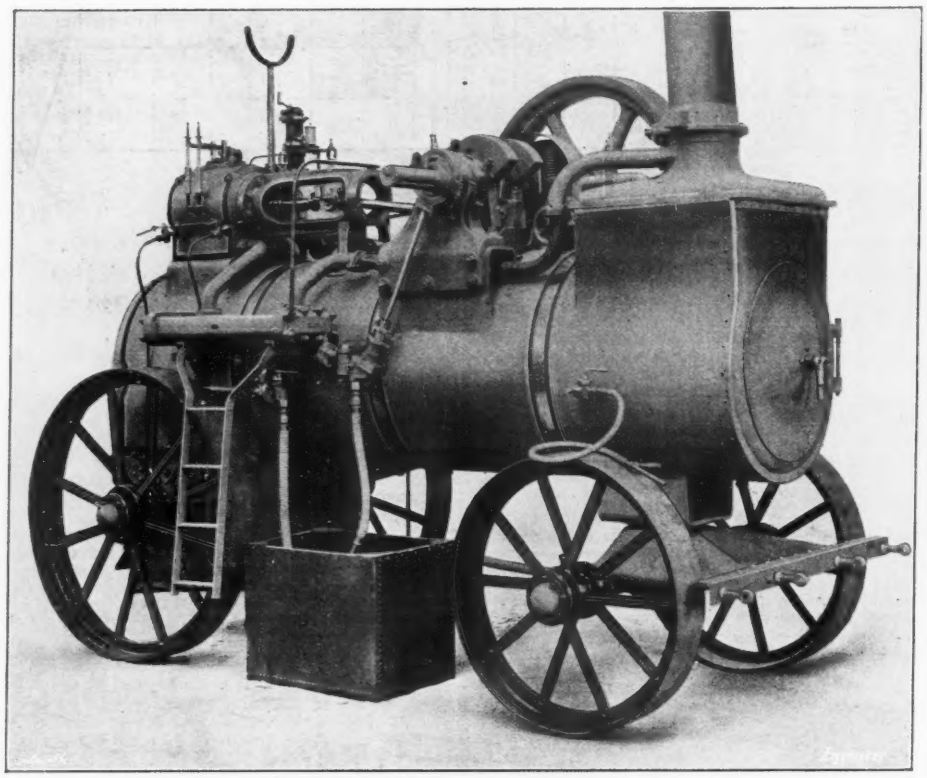
Portable engines with superheaters have been made abroad for several years, and with a view to seeing what can be done in the same direction in this country Messrs. Richard Garrett and Sons, of Leiston, have recently completed a small engine which will be exhibited at the Smithfield Club Show next week.

It is a single-cylinder portable, developing about 25 horse-power at 200 revolutions. The cylinder is placed at the fire-box end, and steam is distributed by a piston valve. The valve motion is very simple, and the admission is controlled by a shaft governor and shifting excentric. On the right of the engine is fitted an exhaust steam feed heater. It consists of a cast iron box containing copper tubes, through which the feed passes on its way to the boiler, whilst exhaust steam on its road to the chimney traverses the box itself.

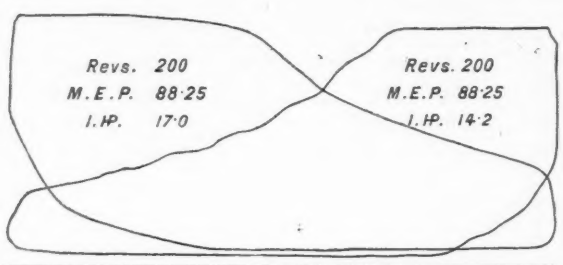
The superheater is the feature of principal interest. It is placed in the smoke-box, which is enlarged and modified in shape to accommodate it. It is very simple in construction, consisting of two long cast steel boxes or headers connected by a number of zig-zag steel tubes. The lower box is placed horizontally immediately above the top row of boiler tubes, and close to the tube plate. The upper box is immediately above the lower one, and being of the same length the sides of the smoke-box have to be carried up parallel to let it in. The superheater tubes are bent zig-zag several times, and they lie parallel to each other and fore-and-aft of the boiler. The area of the superheater is about 66 square feet. The steam enters the top box by a short bend direct from the boiler, and after passing through the tubes, leaves by the lower box, and is led by an exterior well lagged pipe to the valve chest. It will be noticed that the position of the superheater is such that it does not prevent easy access to the boiler tubes; and secondly, that the course of the steam takes place in the theoretically right direction, the colder steam meeting the colder gases. The whole thing is extremely simple and free from complication of any kind. The tubes are bent to a simple shape, and they are expanded into the boxes in the ordinary way. Unequal expansion cannot affect their staunchness, as their form renders them elastic. They leave a clear run for the gases, and are readily accessible for cleaning either with a brush or steam blast, and, finally, the lower half of the smoke-box is left as open and free as in a saturated engine. The tubes can therefore be brushed in the ordinary way, and no special appliances are required. It might almost be supposed that it would not be worth fitting a superheater to so small an engine, and one intended for farmyard work, but when the simplicity of the design is considered its adoption appears quite natural. The only unusual feature about the whole engine is the large positive action lubricator which is a necessity with higher temperature steam.

We were given an opportunity of running a short test with this engine on Friday last at the Leiston works, and confirmed figures obtained previously by the makers themselves.

The trial lasted 154 minutes, and although it was not possible to observe all the refinements of a highly scientific experiment, the results may be regarded as substantially accurate, and indicative of what might be expected from a similar engine in ordinary every-day work. The conditions were absolutely normal, with the exception that the engine was under cover and that the grate area was reduced by fire-bricks put in at each side to 2¾ square feet.



SINGLE-CYLINDER PORTABLE SUPERHEATED STEAM ENGINE



CARDS FROM SUPERHEATED STEAM PORTABLE

This was deemed advisable in view of the fact that a good Welsh coal was to be burned. The grates of portable engines have to be made large enough to burn poor fuel, and had the whole area been employed with coal of the quality used the management of the fire would have been difficult. The analysis of the coal shows that it gives 13,247 B.Th.U., has 3·85 per cent. of ash and ·75 of moisture. The heating surface of the boiler is 150 square feet, and it is fitted with a Garrett corrugated fire-box. The diameter of the cylinder is remarkably small for the power developed, and we were informed that as originally designed the engine gave more than the desired power, and the cylinder had to be re-lined. The temperature of the steam was taken at the steam chest, in which a pocket containing mercury was fashioned. It varied slightly, falling once or twice to 500 deg. Fah. and rising now and then to 515 deg. Fah. It would be safe to take it as averaging 510 deg. Fah. The temperature of the smoke-box gases just after they had passed over the superheater tubes varied between 495 deg. Fah. and 525 deg. Fah., and it was, curiously enough, sometimes higher and sometimes lower than the steam temperature.

The feed-water was measured into a tank beside the boiler, and fed by a plunger feed pump through the exhaust steam feed-water heater into the boiler. Its temperature after passing the heater, as measured at the return or overflow cock, averaged approximately 150 deg. The temperature in the tank varied between 95 and 120 deg. Fah.

A rope brake on a water-cooled fly-wheel was used. The spring balance was suspended above and the weights below. The action was not entirely satisfactory, and the horse-power gradually increased as the run progressed. There was, however, no appreciable difference in the engine speed, which never varied more than one revolution above or below 200. It was obvious that the simple shaft governor of improved design acted excellently.

The brake wheel was 61in. diameter, which is as nearly as possible 16ft. circumference. The permanent load was 308 lb. The average reading on the spring balance was 36 lb. The net load on the brake was therefore 272 lb. average. The rim of the wheel at 200 revolutions per minute covered 3200ft. per minute. Hence we have—

$$\frac{272 \times 3200}{33{,}000} = 26{\cdot}37 \text{ B.H.P.}$$

The measurement of the coal was not as precise as it might have been, owing to the difficulty of estimating the amount on the grate at start and finish. The fall in pressure method was used, the trial starting and ending when the pressure had fallen 5 lb., and was declining. The results of this method, where such small quantities and short times are in question, as was the case during the present test, are always open to some doubt, as the difference of a few pounds is sufficient to alter the result. Our impression from the condition of the fire at the end of the trial was that, if anything, a few pounds should be allowed in favour of the engine, but we have preferred to take the results as they stood rather than make allowances for possible errors. The actual coal consumed was 150½ lb. in a run of 154 minutes, or at the rate of practically 58½ lb. per hour. Taking the average horse-power as 26·37, we find the coal consumed per B.H.P. per hour reached no more than 2·2 lb., which is a remarkable result for so small an engine.

The consumption of water was at the rate of 595 lb. per hour, giving a steam consumption of about 22¼ lb. per brake horse-power per hour, and an evaporation of over 10 lb. of water per lb. of coal.

Indicator cards were taken at intervals of about 15 minutes, and we give a reproduction of one pair. The speeds and the brake load were taken at the same time, so that the mechanical efficiency might be calculated. It works out at slightly over 90 per cent., a good result, due, no doubt, in part to the use of a piston valve, which, although it involves large clearances—about 10 per cent. in the present engine—yet saves much in mechanical loss. It will be observed, by the way, from the indicator cards that in order to compensate for the large clearance a fairly high compression pressure is used.

The general results are tabulated below for ease of reference, and it is only necessary to add in conclusion that the engine has only been at work about one week, and is therefore probably not yet up to its maximum, and that it ran quietly and without a hitch of any kind during the test.

Single-cylinder portable engine with superheater.—Tested at Leiston November 29th, 1907.

Duration of trial	154 minutes.
Pounds of coal burned	150½
Calorific power of coal	13,247 B.Th.U.
Pounds of water evaporated	1530
Temperature in tank (average)	103° F.
Average B.H.P.	26·37
Pounds of coal per B.H.P per hour	2·2
Pounds of steam per B.H.P. per hour	22¼
Average I.H.P.	29½
Pounds of coal per I.HP., per hour	2
Pounds of steam per I.H.P per hour	20·2
Mechanical efficiency $\frac{\text{B.H.P.}}{\text{I.H.P.}}$	90

We give also the results of three trials run by the makers themselves:—

Date of trial	1907 Nov. 27	1907 Nov. 28	1907 Nov. 29
Duration of trial	210 min.	203 min.	215½ min.
Steam pressure	170 lb.	170 lb.	170 lb.
Total water used	1942 lb.	1545 lb.	2150 lb.
Total coal used	224 lb.	168 lb.	224 lb.
Revolutions per minute	196	195·4	201
Temperature of feed	150 deg.	142 deg.	142 deg.
Temperature of superheat	515 deg.	492 deg.	521 deg.
Temperature of flue gases in funnel	493 deg.	472 deg.	545 deg.
Brake horse-power	24·25	18·71	26·4
Indicated horse-horse	27·8	20·8	29·33
Mechanical efficiency	87·5 p.c.	90 p.c.	90 p.c.
Water per hour per B.H.P.	22·85 lb.	24·2 lb.	22·7 lb.
Coal per hour per B.H.P.	2·64 lb.	2·64 lb.	2·36 lb.
Water per hour per I.H.P.	19·95 lb.	21·8 lb.	20·42 lb.
Coal per hour per I.H.P.	2·3 lb.	2·39 lb.	2·12 lb.
Water evaporated per lb. of coal	8·66 lb.	9·13 lb	9·6 lb.

A THOUSAND TONS A DAY.

The records of the great Cunard Atlantic liners, the Lusitania and her so-called sister, the Mauretania, are watched with augmented interest as time passes. First, we had the race with the German liners. They have been beaten. Now the competition is between the Lusitania and the Mauretania. It is too soon to venture on an opinion. It is not too soon to say that facts, not opinions, so far, go to show that the Mauretania will be the faster ship of the two. They are both experiments, and that to a far greater extent than appears at first sight. The propulsion of an Atlantic liner by turbines is one novelty, the propulsion of an Atlantic liner by four screws is another novelty, and an ocean speed of 25 knots will, indeed, be a new thing under the sun.

While so much is uncertain, some things are, at least in a way, certain, and the data which follow will, we think, prove startling even to engineers accustomed to deal with large ocean ships. The Lusitania and her sister are alone in their dimensions, their power, and their speed. The scale on which they do things is colossal. It is true that precise figures, so far, have not been published, but enough is known to permit fairly accurate conclusions to be drawn.

It is not denied that the coal consumption is about 1000 tons every twenty-four hours. It may be a little less or a little more. The bunkers hold 7000 tons. How much remains in them at the end of each trip is only known by a select few. We take it for granted, however, that each ship burns 1000 tons of coal every twenty-four hours—that is to say, the contents of the trucks of two 50-wagon coal trains, one train for the day and the other for the night. As there are twenty-five boilers, each boiler must take 20 tons per day and the same every night.

It may be assumed that, the boilers being Howdenised and the coal good, each pound of coal will make 9 lb. of steam; that is to say, no less than 9000 tons of steam are made every twenty-four hours, or, neglect-

THE CENTRAL HALL, FRANCO-BRITISH EXHIBITION

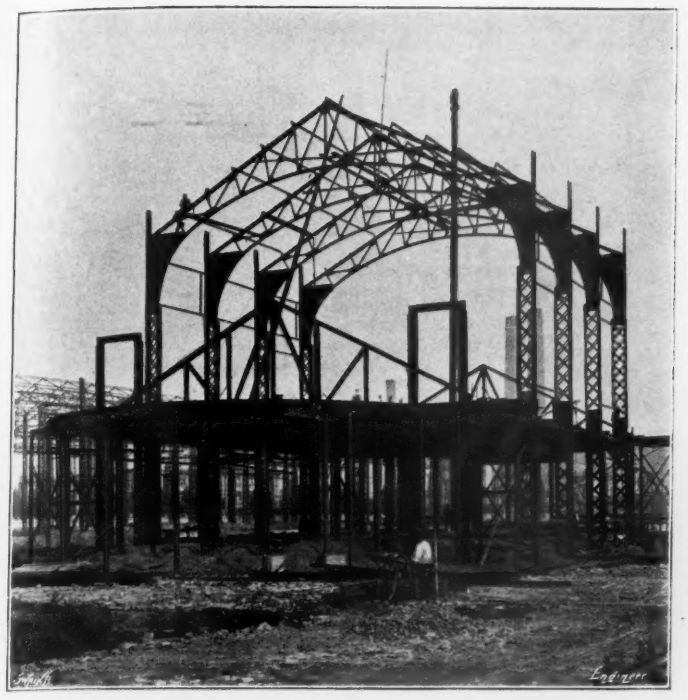


Fig. 1

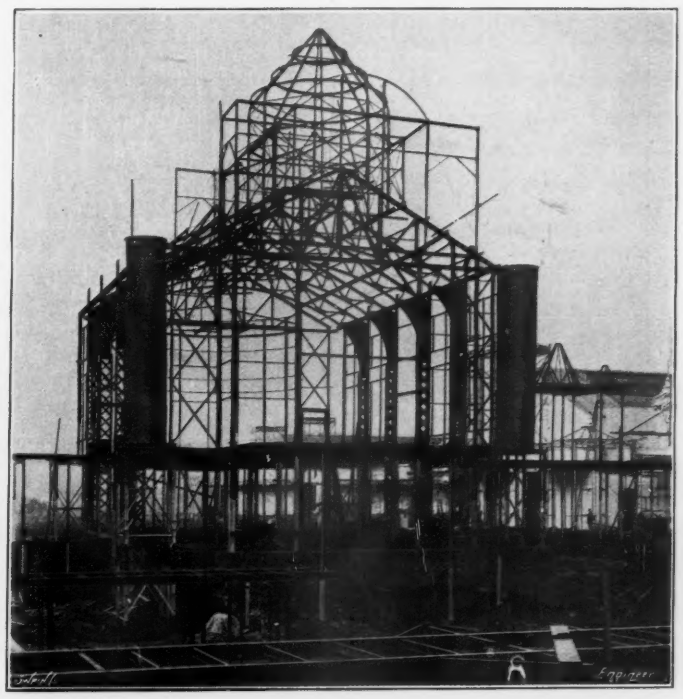


Fig. 2

ing fractions, 375 tons of steam pass per hour through the engines. As the pressure is about 200 lb. absolute, each pound of steam will occupy about 2 cubic feet, which means that 1,680,000 cubic feet of steam pass through the engines every hour.

These are large quantities, but they shrink when compared with the flow of water through the condensers. That will be about 50 times the weight of the feed-water, or $50 \times 9000 = 450{,}000$ tons per twenty-four hours, or 312 tons of water every minute, or 100,800,000 gallons per day. To realise what this means, it will suffice, perhaps, to say that the quantity would represent the water supply at 35 gallons per head per day of a city with nearly three million inhabitants, or almost enough for the city of Paris. It is a fortunate circumstance that there is plenty of water in the Atlantic Ocean.

Turning to the furnaces, we have equally astounding figures. Allowing 20 lb. of air per pound of coal, we have 20,000 tons of air passing through the grate bars every day. Taking the temperature of the supply at 100 deg., we have 14 cubic feet of air to the pound, so that 26,100,000 cubic feet of air enter the furnaces every hour. A pipe 10ft. square would pass this quantity if the speed were that of a great gale—50 miles an hour.

We do not know with any certainty what the power developed is. Taking it at 60,000 indicated horse-power at 24 knots, we find that a thrust of 353 tons would represent that power; but making the usual allowances, we may take it that the total net thrust is probably somewhere about 180 tons, or, say, 45 tons for each propeller.

We have taken it for granted that the power developed on the shafts is 60,000 horses, but of this we have, as stated above, no certainty. The consumption we have taken at 1000 ons for all purposes. This represents only 1·55 lb. per effective horse-power per hour. This means an exceptionally high economic efficiency, when we bear in mind that it stands for power delivered to the propeller shafts, and includes all the auxiliaries. We not unnaturally ask ourselves whether the power is not less than 60,000, which would account for the failure of the ship to maintain 24·5 knots; or whether the consumption of coal is not greater than the gigantic figure named? If, including all auxiliaries, the consumption of fuel is really only 1·55 lb. per net horse-power per hour, then the economic triumph of the turbine on the Atlantic is indeed remarkable.

THE FRANCO-BRITISH EXHIBITION.

No. II.*

WE continue below our description of the buildings now being erected for the forthcoming Franco-British Exhibition.

The Central or Congress Hall with its approaches weighs about 1300 tons, and it is probably the heaviest of all the buildings for the area which it covers. It is being constructed by the St Pancras Ironwork Company, Limited. In Figs. 1 and 2 at the top of this page we give two views of the Central Hall which show the building in two stages of construction, and from different ends. The eight main supports are latticed columns, each built up of 12in. channels, with alternate plates and lattice bars, as the case requires. They have a girth of 74in., and they each weigh 3¾ tons. The steel base area is 10 square feet. Considering the unsupported height of the building, the unusual projections and domes, the great wall surface, the nature of the soil, and the single-arched span of the roof, it was thought desirable to lace these bases together, or form an open grillage of ties from column to column to prevent any possibility of sliding. These ties are 5in. by 3in. R.S. joists, buried in the concrete below the floor level. There are seventy-two columns at the lower level, fourteen of which stop at the first floor level to support the inner area of the floor. These latter columns are of single-rolled 10in. by 6in. I section, each supporting its share of area, namely, 320 superficial feet, weighing 28½ tons. This floor, which is about 22ft. above the artificial lake, has an area of 6700ft., and a calculated load of 600 tons. It is a network of steel composed of 10in. by 5in. I section for the secondary main floor joists, and 5in. by 3in. cross joists. For the main cross beams it was necessary to use a section of considerable strength, and a section 18in. by 7in. of heavy make was found to suit the case admirably. These beams are secured to the main columns at the side of the building with built-up brackets of plates and angles, projecting 2ft. They rest on and are secured to the interior column, and form a stiff connection between the opposing columns on either side of the building.

The secondary joists are 5in. below the top flange of the main beam, and the concrete joists are laid on the top of the 10in. by 5in., so that the lower flange of the 5in. by 3in. and the upper flange of the 10in. by 5in. form the necessary shelving for the 7in. of concrete of which the floor is composed. In this way expensive complications are dispensed with. At each end of the floor there is a step down of 6in. to the level of the balconies, the balcony at the lake end being shaped with a portion cantilevered out to project over the cascade which runs down from this level into the lake below. The balcony at the other end is of semicircular shape, supported by sixteen 6in. by 5in I section columns. Eight of these columns on the outer or 27ft. radius stop at the first floor, and are connected to the 8in. by 4in. facia joists and 5in. by 3in. concrete joists, which form a 7ft. semicircular balcony running round the gable end. The inner columns, which are at a radius of 20ft., run right through the floor, and are carried up to the level of the eaves to form the groundwork of a magnificent semicircular gable. The wind stress which is taken up by the large lattice columns in the centre portion of the longitudinal sides, is in turn taken up at the corners by a complication of compound stanchions and diagonal cross bracing. The compounds are placed 7ft. apart, and act as the flanges or booms of a girder, fixed at one end to the ground, the whole of each supporting the roof framing of the gable ends. This framing, in the form of a hipped truss with double members, answers the dual purpose of supporting the roof and dome on the top and the lean-to framing of the projecting gable ends, the roof of which reaches a lower level.

The four main trusses are of girder type with rafters and ties of double angle section, 60ft. span and 16ft. centres, arched at the underside to a radius of 46ft., which runs for a length of 48ft., and then breaks on a tangent with a quadrant at each end, 12ft. 6in. radius, and finishes in a vertical line to the lattice columns. The rafters, which are 6½in. by 3½in. double angles placed ½in. apart, are at 27 deg. pitch, and the whole of the minor members are of 3in. and 2in. double angles, with the exception of the centre ties, which are of two small channels back to back. The main ties are 5in. by 3in. double angles, also ½in. apart, riveted up at the ends to $\frac{5}{16}$in. plate, which connects them to the rafters and the columns, forming a large plate and angle bracket, 11ft. long by 8ft. girth, each bracket weighing half a ton. These trusses may appear to err on the heavy side, but it should be borne in mind that the whole of the superstructure is dependent on these trusses and stanchions.

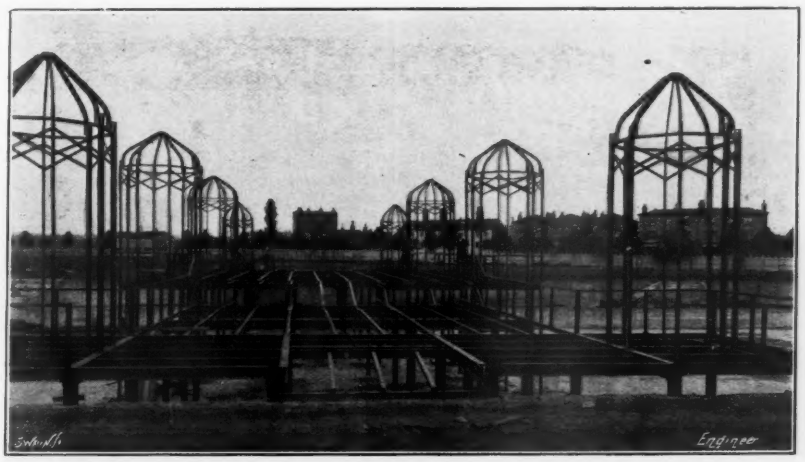


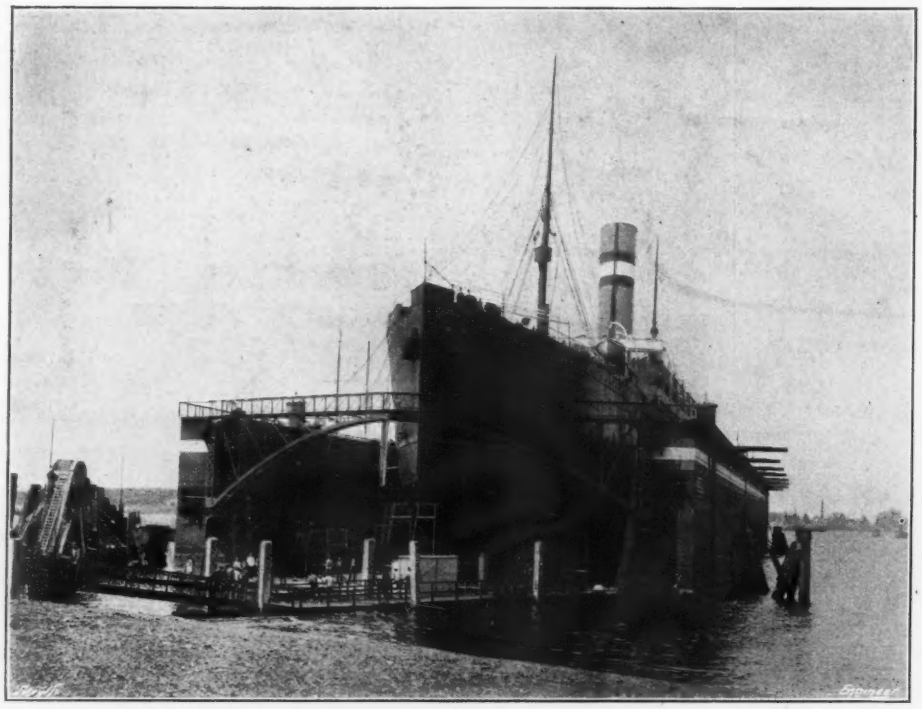
Fig. 3—BRIDGE OVER THE LAKE

The maximum calculated allowable stress in the rafters due to the dead load and wind pressure is 36 tons, which is mainly due to the domes alone. The stress in the main ties due to the same cause amounts to over 27 tons. These latter stresses are partly due to the reaction of the wind from the main columns, the trusses being designed to balance the forces between the windward and the leeward side as far as possible. The weight of one truss complete is 2¾ tons.

The roof is of the lightest description possible consistent with strength. Two rows of 8in. by 5in. I section purlins run from end to end 11ft. from and parallel to the eaves, to assist in taking up the stresses; otherwise the purlins are 4in. by 1¾in. I sections, placed 5ft. 6in. apart,

* No. I. appeared November 29th.

NEW FLOATING DOCK AT ROTTERDAM



and the ridge 4in. by 3in. I section. The purlins are bolted together with ⅜in. sag rods, the whole being covered with 20-gauge galvanised corrugated sheets, which are secured with Limpet patent bolts and washers. Inspection of the gutter, which runs on both the longitudinal sides at the level of the eaves, is apt to give the impression that it is of unduly heavy section. We are informed, however, that this particular item was the subject of very careful calculation and consideration. It being found necessary to resist and distribute the wind pressure due to the gables and domes with a section of large radii, a joist of suitable section to take the whole and at the same time support an ordinary gutter was found to be unquestionably the best practice to adopt. To distribute the racking stresses a series of diagonal ties have been provided in the roof.

The walls of the building are supported by the same method as the other buildings of the Exhibition, viz., with 8in. joists placed from 4ft. to 6ft. apart horizontally for carrying the concrete slabs.

The framework of the six domes, which is entirely supported by the trusses, is octagon in shape. The two main domes are 26ft. across, and the four small ones 10ft. They are mostly constructed of 5in. by 3in. ribs with channel and joist horizontal framing. To shape the domes 6¾in. by 2½in. channel rings have been bracketed to the ribs at intervals of 5ft., terminating in a heavy cast iron cap and ring. The height of the large dome is 110ft. above the stanchion bases. On each side of the hall from the first floor there are two flights of steps 5ft. 6in. wide, inlaid with the St. Pancras Ironwork Company's non-slip concrete treads. There are entrances and exits on both floors in direct communication with the grounds, those most deserving of note being what are termed the "approaches."

The buildings and grounds being symmetrical on both sides of the hall, it was necessary to have these approaches on the two sides. They are each 130ft. in length and 20ft. wide, running along at the edge of the lake with a domed kiosk in the middle of each. The lower approach is about 3ft. above the lake level, and the upper 15ft. above this. The upper floor is of steel and concrete, the main joists, which measure 12in. by 5in., running transversely, and resting on 5in. by 4½in. columns spaced approximately 7ft. and 8ft. apart. These columns are 31ft. long, having to run down 12ft. into the ground and 3ft. below the bed of the lake. They are reinforced 12ft. from the bases with concrete buttresses. The concrete joists are similar. The first floor of the central hall and the domes on the kiosks are also of the same construction as those of the central hall.

A curious feature of the building is the two water tanks to be seen at the sides of the building in Fig. 2. These tanks, which are 30ft. long and over 21ft. in circumference, are placed on steel platforms at a height of 25ft. above the lake level. They are of rolled steel plate, and secured to the platform by brackets, a steel band one-third from the top being secured to the two stanchions at each corner of the building at the lake end. Water is to be continually pumped into these tanks, and used for the cascade below. The gross weight of the tanks, together with the towers on which they stand, is 65 tons, and each tank holds 11,000 gallons. It is interesting to note that in these structures there are 68,900 parts, including 2380 of the I beam section, the remaining being L's, T's, channels, &c. The whole of the work was carried out on the American principle of figured scheduling, 688 separate details having been made. These details, which are not drawn to scale, are sent into the works, and the whole of the material is manufactured and delivered, holed, and bracketed, and marked ready for erection without entailing setting out, and, in many cases, assembling at the works. In Fig. 3 we give a view of a bridge across the lake, which is also a portion of the St. Pancras Ironwork Company's contract.

FLOATING DOCK AT ROTTERDAM.

THE port of Rotterdam, which is the second most important port in Holland, Amsterdam being the foremost, has recently acquired a large new floating dock. It has been designed to take the largest ships which sail to Rotterdam, or which are attached to that port. Some idea of the size of the dock may be gathered from the illustrations which we give of it above and on page 569, and from the fact that its leading dimensions are 565ft. in length, extreme breadth 120ft., and height 50ft. Allowing for the width of the sides, a space of 88ft. is available at the bottom of the dock, and 96ft. at the top. The height of the inside from the flooring is 36·6ft. The sides rest on seven independent pontoons, each measuring 120ft. in length by 79ft. breadth by 13ft. in height at the centre, tapering to 12ft. at the sides.

These pontoons are so arranged as to leave a space of 23½in. between each of them, and they are separately connected to the sides of the dock by bolts, rubber packing being used to ensure a water-tight joint. This arrangement allows any of the pontoons to be easily detached and to be brought up inside the dock. Each pontoon consists of twenty-four frames 120ft. in length, the two outside frames being solid. There are also three transverse water-tight bulkheads which divide each pontoon into four water-tight compartments. There are large channels at the bottom of each compartment for draining off the water when the dock is raised. Each pontoon weighs about 600 tons, thus making a total weight of 4200 tons. The side caissons are each 33½ft. in height, and at the bottom are 16ft. broad, tapering to a width of 12ft. at the top. They are strengthened by girders spaced one metre apart. The framework is covered by mild steel plates, and the upper surface, which is covered with chequer plates, is, of course, a platform. The floor on which the machinery is placed occupies the whole length of the side caissons, and is situated about 6 m. from the top of the dock. A number of windows have been provided for lighting this compartment. Under the machinery room there is another compartment, perfectly water-tight, which can be filled with water when it is desired to lower the dock. The total weight of the side caissons is 1800 tons. Besides the ordinary platforms on the top of the sides, there are two others, 6 m. and 8·5 m. respectively above the floor of the dock, which are carried on brackets riveted to both the side caissons. These galleries can be clearly seen in one of the engravings. At both ends of the dock there are two iron staircases, which connect these platforms with the top and bottom of the dock. There are also two iron ladders in the centre of the platforms. In order to pass from one side to the other when the dock is submerged, a small swing bridge is provided, as shown above. The arms of the two girders are 16 m. in length, and they are pivoted at the sides of the dock. Three iron staircases have been erected in each of the side caissons to allow of a connection between the top platform and machinery room. A small hut, 9 m. by 3 m., containing all the controlling apparatus for working the dock, is situated on the top platform.

The pump wells are between the machinery room and the bottom of the dock. In all there are fourteen pumps, two being placed in each pontoon. The filling pipes are 15¾in. in diameter, and the discharge pipe about 11¾in. Filtering gauze is placed in front of all the pipes. The pumps are of the centrifugal type, and have a capacity of 20 cubic metres—approximately 4409 gallons—of water per second. All the pumps and stop valves are controlled electrically, each valve and each pump having a special motor. So as to be able to remove the last traces of water from the small channels in the bottom of the pontoons, there are four pumps of the Lenz type, having a capacity of 50 cubic metres per hour—about 11,022·5 gallons per hour—and the air chambers of the pumps are capable of supporting a pressure of 10 atmospheres. These electric pumps also work on a pipe of 100 mm. in diameter, which leads down from the side caissons to within 1 m. of the floor level. Vertical pipes branch off near the top of the dock sides. Valves are fitted to the ends of these branches, and flexible tubing connected for cleansing the dock, &c., and also in case of fire. The controlling switchboard is placed in the machine-room, which controls the sluice valves for the bulkheads. Gauges or pneumatic indicators are provided for telling the level of the water in the dock, and also for indicating the height of water in each of the twenty-eight compartments. Moreover, there is a device for showing the inclination of the dock in all directions. Each pump motor has its own small special switchboard, and the working is controlled by an attendant under the orders of a dock master. Each machine-room has one attendant, who also has to look after the pumps.

The ships admitted to the dock are secured in the usual manner by chocks and supports, and there are eight capstans on the top platform of the two sides for facilitating the work of securing the vessel. The ships are towed into position by means of two electric capstans. The dock is well lighted artificially by a number of electric incandescent and arc lamps, the smaller lamps being more particularly used in the machinery rooms. Independently of the load of 4200 tons—the weight of the pontoons—and 1800 tons of the side caissons, there is also a supplementary weight of about 500 tons due to the machinery. Thus the total weight of the dock is about 6500 tons. It can raise 16,000 tons, and is capable of receiving ships up to 18,000 tons.

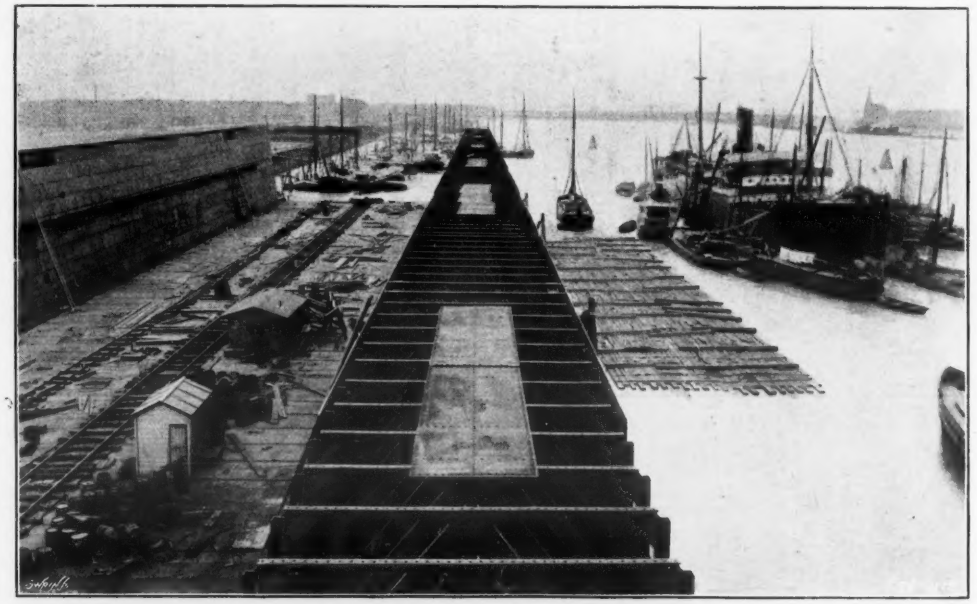
The whole of the work has been carried out by Aug. Klönne, of Dortmund, at a total cost of 1,812,000 marks, which is approximately £90,600. This shipbuilding yard is situated on the north of the new basin of the river Meuse, and occupies a ground area of about 18,000 square feet. Special dwelling-houses have been erected there for the workpeople, besides large offices. The firm possesses a good dry dock, which has an inclination of 1 in 15, and the yard has been protected against the ravages of storm and of the tidal race by an elevated dam. Some piles 15 m. in height had to be used to allow of the construction of the slipway, which is 24 m. in width. There is a movable crane to each slipway, each one having a reach of about 93ft., and capable of lifting a weight of eight tons. Railway lines are constructed all the shipyard for the wagons which bring the material to the work.

The construction of the dock was proceeded with as follows:—The bottoms of the pontoons were assembled on the ways, where they were riveted; at the same time, the bracings were being put together in lengths of 36 m. by 4 m., and these were then placed by the winches in position on the pontoons. The latter were then connected together in the harbour just in front of the slipway, and after the launching of the last pontoon they were all brought back in front of the yard. The materials used for the construction of the deck of the pontoon and also for the sides were carried to the work by means of a jetty projecting for 30 m. into the harbour. As is shown on page 569, a standard gauge railway was laid down on the pontoon, and a steam crane carried the materials along the line, which was 170 m. long. Outside, temporary brackets were used for carrying the rails for a 6 m. crane. A travelling crane, 13 m. high, with a capacity of 5 tons, was used in the construction of the side caissons. The trial of the dock, made with the steamer Potsdam of 1200 tons, demonstrated that such a ship could be brought in and fixed in two hours, and we are informed that the side caissons showed no deflection.

ELECTRICAL EXHIBITION, 1908.—An electrical exhibition is to be held next October in Manchester, and to it we understand, not only have the Corporations of Manchester and Salford given their support, but also the majority of corporations, district and urban councils, and supply companies in the surrounding district. A meeting of the electrical trade has been convened, and will be held in Manchester at the Board-room of the Chamber of Commerce, 44, Mosley-street, this afternoon at 4 p.m. The President of the Chamber will be in the chair. Another meeting, convened by Sir Wm. Preece, is to be held in London on Thursday, the 12th December, at 4 p.m., at the Hotel Cecil, thus giving members of the industry an opportunity of attending whichever meeting is most convenient to them. It is proposed to put the following scheme into effect:—An influential president is to be elected, as well as a vice-president or presidents. A list of patrons will be secured, and a General Committee is to be appointed, consisting of:—(*a*) Five representatives of corporations or councils contributing to the funds; (*b*) two representatives of supply companies contributing to the funds; (*c*) two representatives elected by the Institution of Electrical Engineers; (*d*) one by the Municipal Electrical Association; (*e*) three representatives of the National Electrical Manufacturers' Association; (*f*) two representatives of the Electrical Contractors' Association; and (*g*) five representatives from among the general exhibitors. From this General Committee an Executive or Acting Committee will be appointed, with full powers to carry out the scheme on behalf of the main Committee. Hon. consulting engineers are Mr. S. L. Pearce and Mr. V. A. H. M'Cowen; the general manager is Mr. C. S. Northcote, M.I.E.E., and the organising secretary Mr. W. Davenport. Any profits arising out of the exhibition will be allocated:—(1) In a percentage return to exhibitors; (2) a percentage return to donors; (3) a percentage to be contributed to charities connected with the electrical industry; and (4) the surplus, if any, is to be dealt with by the Committee.

NEW FLOATING DOCK AT ROTTERDAM

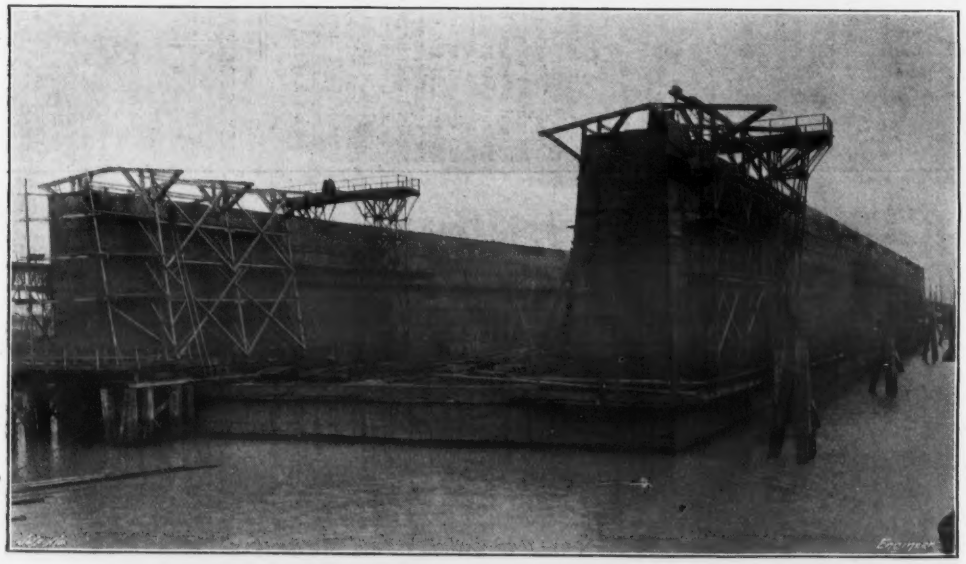
(For description see page 568)



CONSTRUCTING ONE OF THE LATERAL CAISSONS

ERECTING THE DOCK

CONSTRUCTING THE PONTOONS



THE DOCK NEARLY COMPLETED

A NEW FLAME ARC LAMP.

A FLAME arc lamp possessing some novel and interesting features has recently been placed on the market by Crompton and Co., Limited, who have secured a licence for the manufacture and sale of the flame lamps and carbons made under patents held by M. André Blondel. The Blondel lamps have been in use for some considerable time on the Continent, and have, we are informed, met with a great deal of success, particularly in Paris, where they are largely used for street lighting, and at the Milan Exhibition, which was lighted throughout by them. Crompton and Co., Limited, are now making these lamps at their works at Chelmsford, and selling them under the title of the Crompton-Blondel flame

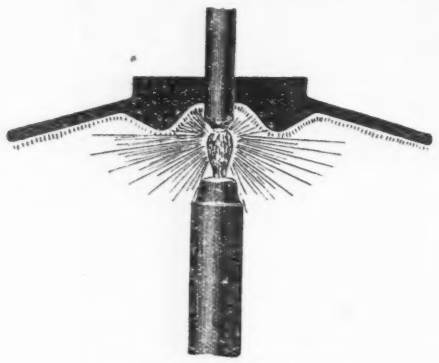


Fig. 1—FLAME ARC CARBON

lamp. For this purpose the design of the firms "S" type arc lamp has been modified, and new features have been introduced, notably with regard to the arrangement of the carbons—the positive being below the negative—and the ventilation of the globe.

The carbons used are heavily mineralised, and give a long and curiously-shaped flame of great intensity, emitting light of a pale yellow or primrose colour. The colour is described as being a mean between the orange-coloured light given by

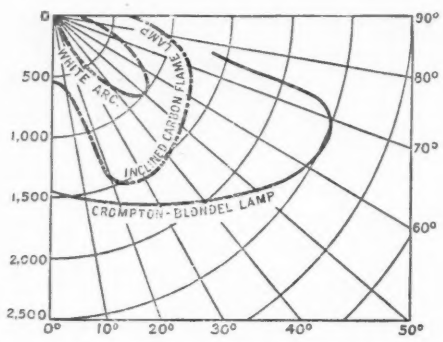


Fig. 2—CANDLE POWER DISTRIBUTION

most of the inclined carbons lamps and the white light of the ordinary arc. Fig 1 shows a sectional view of the flame arc, carbons, and economiser. It is pointed out by the makers that most of the light is given out by the flame itself, which is of some considerable length. Other light comes from the incandescent ends of the carbons, and a certain amount is reflected from the surfaces of the economiser, which is said to become rapidly covered with a very fine white deposit well suited to this purpose. We have been supplied by Messrs. Cromptons with comparative curves showing the candle-power distribution

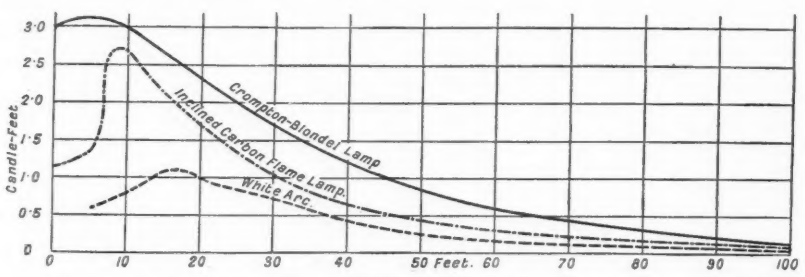


Fig. 3—RELATIVE ILLUMINATION

for this lamp, and also for an ordinary white arc lamp, and an inclined carbon flame lamp. These curves are reproduced in Fig. 2. It is pointed out that at angles near to the vertical both types of flame lamp are greatly superior to the ordinary lamp. At 45 deg. the inclined flame is about twice and the Crompton-Blondel about three times as powerful as the ordinary arc, and at angles between 55 deg. and 75 deg. the Crompton-Blondel is about four times as powerful as the ordinary arc, and more than twice as powerful as the inclined carbon lamp. High candle-power in directions near to the horizontal line is of great value for lighting streets, open spaces, factories, buildings, &c., where it is advisable to have an even distribution of light.

We have also been supplied with the curves shown in Fig. 3, which give the illumination in candle foot units from the three lamps referred to above. Messrs. Crompton claim that while this diagram shows that the inclined carbon flame lamp produces a high illumination at about 10ft. from the post, the effect rapidly falls off further away and eventually becomes but little better than that of the ordinary open type, but that, on the other hand, the Crompton-Blondel lamp gives an equally high illumination near to the post, and the falling off is less rapid as the distance increases. Thus an illumination of one candle foot is obtained at 20ft. with an ordinary arc, at 30ft. with an inclined carbon flame, and at about 47ft. with a Crompton-Blondel.

Referring again to the curves in Fig. 2, the mean hemispherical candle-power computed from these give 450 for the ordinary, 1125 for the inclined, and 1850 for the Crompton-Blondel. It is not, however, correct to assume that the mean hemispherical candle-power is a true measure of the usefulness of a lamp. A good illumination depends more on the shape of the curve than the mean value. A theoretically correct curve would be one in which the candle-power at any angle is proportional to the square of the distance through which the light travels before striking the point of observation. This ideal curve is unfortunately beyond the reach of any known arc lamp, but the curve of the Crompton-Blondel approaches nearer to it than either of the other two. In these diagrams the figures for the Crompton-Blondel lamp are, we are informed, taken from a series of tests carried out at Devonport Dockyard, where upwards of two hundred of these lamps are in use. The other two curves are taken from an article by Mr. Kenelm Edgecumbe published in the electrical papers of July 4th, 1907.

The Crompton-Blondel lamp is made in six standard sizes, three with a single pair of carbons and three with two pairs, and they will burn for periods varying from eight to forty-five hours. This is done without the use of a magazine or any similar contrivance to complicate the mechanism, and require continual attention.

The mechanism and general construction of the lamp are almost identical with the Crompton "S" type lamp. Special attention has been given to the ventilation of the globe, as the proper direction of the air currents has an important bearing on the correct formation of the flame and the disposal of the products of combustion. There is no leakage into the chamber containing the mechanism, and, consequently, very little cleaning and no more repairs are required than in the case of the ordinary open type arc lamp. Messrs. Crompton are, they inform us, now substituting these lamps for the older open type lamps in their shops at Chelmsford, where the lighting is entirely by arc lamps, no incandescents being used. The new lamps are said to take 250 watts, against 400 and 600 watts in the old type, which effects a very large saving in the running cost of the shops.

METROPOLITAN RAILWAY PENSION FUND.

THE following memorandum was issued by the general manager of the Metropolitan Railway on November 30th:—

With reference to my circulars of July 23rd and 30th, 1906, the proposed Pension Fund for members of the Company's staff has been approved by the Shareholders, and an Act of Parliament has been passed to enable the Company to establish the Fund. A scheme has now been prepared which has received the sanction of the Directors, and the Fund will accordingly be established on January 1st, 1908. Books of Rules will be ready shortly, and will be supplied in due course to all members of the staff who make application for admission and are accepted as members of the Fund. Meanwhile, in order that those eligible for membership may satisfy themselves as to the advantages of the scheme, attention is called to the principal points, which are as follows:—

Any servant of the Company in receipt of wages of Twelve Shillings or more per week, and not being under 18, or exceeding the age of 53 years, who is not entitled to be a member of the Railway Clearing System Superannuation Fund, may be admitted as a member of the Pension Fund.

Everyone eligible to join and who is desirous of becoming a member must make application on the form sent with this Circular. The applicant shall, if so required, produce a certificate of his birth to the Managing Committee

In every other case the Managing Committee will determine whether, and if so, upon what terms, Servants of the Company disqualified by age or otherwise may be admitted as Members of the Fund, and these men may fill up and send in the Application Form.

Members will be divided into four classes, according to their contributions. Applicants must state to which class they wish to belong, and those who are within the prescribed ages, and are not more than 50 years of age on their next birthday, may join either class, but cannot change that class without the consent of the Managing Committee, and on terms prescribed by them.

The classes and scales of contributions by members at the ages shown, and the pensions obtainable at the age of 65, will be as follows:—

PENSIONS PER ANNUM ON ATTAINING THE AGE OF 65 YEARS.

Weekly Contributions by Members from date of joining the Fund until Retirement.

Age next birthday.	Class 1. £25. s. d.	Class 2. £20. s. d.	Class 3. £15. s. d.	Class 4. £10. s. d.
19	0 5	0 4	0 3	0 2
20 to 27	0 5	0 4	0 3	0 2
28 to 30	0 6	0 5	0 4	0 3
31 to 32	0 7	0 6	0 4	0 3
33 to 35	0 8	0 6	0 5	0 3
36	0 9	0 7	0 5	0 4
7	0 9	0 8	0 6	0 4
8	0 10	0 8	0 6	0 4
9	0 10	0 8	0 6	0 4
40	0 11	0 9	0 7	0 5
1	1 0	0 10	0 7	0 5
2	1 1	0 10	0 8	0 5
3	1 2	0 11	0 8	0 6
4	1 3	1 0	0 9	0 6
5	1 3	1 0	0 9	0 6
6	1 5	1 1	0 10	0 7
7	1 6	1 2	0 11	0 7
8	1 8	1 4	1 0	0 8
9	1 9	1 5	1 1	0 9
50	1 11	1 6	1 2	0 9
1	—	—	—	0 10
2	—	—	—	0 11
3	—	—	—	1 0

If a member leaves the service either voluntarily or on notice by the Company—except in cases of dishonesty or fraud on the Company—he will be refunded his contributions with simple interest at 3 per cent. per annum on his total contributions in each year from the last day of such year.

A member retiring owing to incapacity for further service by reason of accident or ill-health after not less than 15 years' membership, and after attaining the age of 55, but before reaching the age of 65, will be entitled to a pension as follows:—

Age at retirement.	Class 1. £ s. d.	Class 2. £ s. d.	Class 3. £ s. d.	Class 4. £ s. d.
55	12 10 0	10 0 0	7 10 0	5 0 0
56	13 15 0	11 0 0	8 5 0	5 10 0
57	15 0 0	12 0 0	9 0 0	6 0 0
58	16 5 0	13 0 0	9 15 0	6 10 0
59	17 10 0	14 0 0	10 10 0	7 0 0
60	18 15 0	15 0 0	11 5 0	7 10 0
61	20 0 0	16 0 0	12 0 0	8 0 0
62	21 5 0	17 0 0	12 15 0	8 10 0
63	22 10 0	18 0 0	13 10 0	9 0 0
64	23 15 0	19 0 0	14 5 0	9 10 0

Provided that if he shall in the judgment of the Managing Committee recover so as to be capable of earning his livelihood wholly or partially as before his retirement, the Managing Committee may reduce or suspend his pension while he is under the age of 65. When that age is reached, the pension to which he became entitled under this rule to be resumed.

A member retiring before reaching the age of 55, owing to incapacity for further service by reason of accident or ill-health, after not less than 15 years' membership, will be refunded his contributions, with simple interest at 4 per cent per annum on his total contributions in each year, calculated from the last day of that year; and in addition the Managing Committee may award him such sum as they think reasonable, not exceeding three-fourths of his total contributions.

A member retiring before reaching the age of 55, owing to incapacity for further service by reason of accident or ill-health, after less than 15 years' membership, will be refunded his contributions, with simple interest at 4 per cent. per annum on his total contributions in each year, calculated from the last day of that year.

If the wages of any member be stopped through ill-health, he may, so long as his name is on the books of the Company, continue his contributions, but after such contributions cease his case shall be dealt with under the preceding Rules, so far as applicable.

If a member dies before becoming a pensioner, the person entitled to receive the same shall be paid a sum equal to twice the member's contributions, but without interest.

If a pensioned member dies before the payments made by way of pension have reached twice the member's contributions, the difference shall be paid to the person entitled to receive the same, but without interest.

The Company will, at the end of each half-year, contribute an amount equal to the contributions of its servants who are contributing members in that half-year.

Delegates will be elected from amongst and by the members. The number to be elected will, subject as hereinafter provided, be based on the number of members of the Fund in each Department in the proportion of one delegate for each one hundred members, with an additional delegate for the remaining members in such department numbering fifty and upwards. Any Department having less than 100 members, but not less than 10 members, shall be entitled to elect one delegate.

The Company will arrange for these Delegates to be elected by the Members as soon as the applications are received and the Pension Fund is started.

The Fund shall be managed by a Committee consisting of three Directors and three Officers of the Company, and three persons to be elected annually by and from amongst the Delegates representing the members.

The special attention of the staff concerned is directed to the many advantages to be enjoyed by becoming members of the Pension Fund. Not only is a Pension secured on reaching an age when the majority of men are past work, but the Fund will serve the purposes of a perfectly safe Life Assurance Society and of a secure Savings Bank. It is also important to bear in mind the fact that the Company will contribute to the Fund a sum equal to that of the Members' payments, and this contribution is credited absolutely to the Fund, and cannot under any circumstances be withdrawn by the Company. All ranks are invited to co-operate in this Pension Scheme, especially the junior members of the staff; and it is hoped that the staff generally will by joining the Fund in large numbers, make it a success, and thereby show their appreciation of the interest the Company is taking in the welfare of its employés by establishing such a Fund and contributing so largely to it.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made at the Admiralty:—

Engineer Commanders.—E. Carter, to the Emerald, for the Fox; F. R. Stuttaford, to the Victory, lent for oil fuel course; V. E. Snook, to the Ganges, for charge of machinery ashore and in tenders, for instruction in mechanical training, and to assist inspecting captain; E. S. Silk, to the Vivid, additional, for the Gibraltar, T. Thorn, to the President, as inspector of gun mountings at Woolwich Arsenal; and J. W. Ham, to the President, as engineer assistant to the director of dockyards and dockyard works.

Engineer Lieutenants.—H. A. Little and W. J. Michell, to the Victory, lent for oil fuel course; H. L. Hammond, to the Essex; G. McEwen, to the New Zealand; W. Rattey, to the Leander, additional, for the Velox, on commissioning; H. E. J. Reynolds, to the Scylla; and W. Denbow, to the Goliath.

Engineer Sub-lieutenants.—B. P. Minhinnick, to the Duke of Edinburgh; C. W. Snell, to the Black Prince; C. S. Youle, to the Roxburghe; E. G. Sanders, to the Lancaster; C. H. Haly, to the Vengeance.

TELEPHONE CHARGES.—The National Telephone Company has issued a Memorandum in reply to a memorial prepared by the Association of Chambers of Commerce of the United Kingdom on Telephone Rates. This memorial was adopted at a meeting held in Liverpool, and was directed against the abolition of the inclusive rate of charge for telephones and the substitution therefor of a scale of charges involving a minimum annual subscription and a certain number of calls, all calls beyond this number being paid for in addition. It would be impossible for us to deal in detail with the whole of the points raised in the memorial and replied to in the Memorandum. The gist of the reply of the company, however, is that the inclusive rate, which it was necessary to charge in the early days of telephony because there were not sufficient data to go on, is unjust in that it favours the large user unduly, and is hard upon the small user. This it is pointed out is specially the case in large cities. It is urged, too, that the flat rate is responsible for much of the delay caused by users not being able to be connected because the subscribers they want are "engaged." The capacity of the telephone is limited, and when a subscriber knows that if he increases his equipment he will practically have to double his payment his inclination is to get through on his existing line as much traffic as possible—with the result that the line is blocked. The net result is that the company intends to adhere to its proposed course of action.

RAILWAY MATTERS.

THE tramwaymen in Leeds who work on Christmas Day are to receive double wages.

THE tunnel connecting the New York subways with the Brooklyn traction system was formally opened on Wednesday, November 27th.

WE hear that the Great Eastern Railway Company intends to ask for parliamentary powers to run steamers to additional ports in the North Sea and Baltic.

THE Austrian State Railway authorities in Vienna have just divided contracts between home firms for 1347 railway carriages and wagons, 33 goods locomotives, 67 passenger engines, and 52 tenders.

A LANDSLIP occurred on Tuesday morning on the North-Eastern line between Thorner and Bardsey. Trains from Leeds could only run as far as Thorner, and the expresses were diverted.

THE Belfast Harbour Commissioners have decided to strengthen the tramway on Queen's-road and to lay a new tramway along Victoria-road and wharf to carry a load of 150 tons at an estimated cost of £5119.

THE *Gaceta de Madrid* of 15th November contains a copy of a Decree granting a concession for the construction of a secondary railway from Benavente to Villanueva del Campo, in the province of Zamora.

THE Taff Vale Railway Company has, we understand, promoted a Bill to empower the company to construct dry docks, floating pontoons, slipways, and other ship repairing accommodation at Penarth Harbour.

AT a recent meeting of the Hartlepool Port Harbour Commissioners it was stated that the North-Eastern Railway Company had decided to commence extensive dock works at an estimated cost of £120,000.

WE hear that the superintendent of railway mail service at Houston, Texas, has called upon the railroads to remove from the windows of mail cars all iron bars which would prevent a man from getting out of the car through the window in case of accident.

THE Canadian Pacific Railway announces that, according to the latest advices received by it, it expects to save the greater part of the cargo of their steamer, the Mount Temple, which struck on the rocks on the coast of Nova Scotia on Sunday night, and possibly the vessel too.

THE Strathcona Radial Tramway, which a short time ago secured a street railway franchise from Strathcona, has purchased a right-of-way into the business centre of this city. The company is now asking running rights over one or two streets which it has to cross to enter Edmonton.

ACCORDING to *Electrical Engineering*, the Burma Railways Company, as an experiment, has had twenty-six of its coaches fitted for electric lighting out of 970 vehicles, and the question as to whether the company shall adopt electricity in lieu of gas in the remaining vehicles is now under discussion.

SOME years ago the Imperial Railways of North China constructed, for the use of the Court, a light line from a point some four miles to the west of Kao-pai-tien, a station on the Ching-Han Railway, 52 miles from Peking, westward to the Imperial tombs, a distance of about 50 miles. There is a daily passenger train over the line.

IT is reported in *Indian Engineering* that Mr. Louis Brennan, the inventor of the Monorail Gyroscopic Railway, has been conducting various experiments on behalf of the Indian Government with a view to testing, among other things, whether an electric, steam or petrol motor would be most suitable for carriages built for use in India.

A REPORT from Calcutta says that the East India Railway Company's agent has issued a circular imposing penalties in the way of stoppage of pay and leave allowances on the recent strikers. The men regard this as a breach of faith, and say they resumed work on the understanding that they would be granted complete immunity. Further trouble is threatened.

AT a recent meeting of the Bradford Tramways Committee the report was received of the sub-committee recently appointed to inspect a new type of tramcar upper deck cover, on which there is no standard running through the middle of the upper deck and the cover is arched, enabling passengers to stand erect. The new cover was approved, and orders given for at once adapting it to twenty five cars.

THE plans for the Rove tunnel, through which the canal from Marseilles to the Rhône is to pass, have been approved. While not the longest tunnel in the world, it will have the largest cross section of any. Its length will be 4½ miles, width 72ft., height 46½ft., and the total cubic contents twice that of the Simplon Tunnel. On either side there will be a 6½ft. roadway for an electric railway. The cost is estimated at £1,380,000, and the time required for its construction seven years.

ACCORDING to an American contemporary, a 16 per cent. street railway grade on Selby Avenue, St. Paul, Minn., has been eliminated by a tunnel on a 7 per cent. grade. This was originally on a cable line, but when electric traction was introduced nearly ten years ago a counterweight system was adopted. The capacity of the line operated in this way became too limited for the traffic requirements, especially since inter-urban cars have been run over this route. A double-track tunnel has therefore been built, 920ft. long, with approaches aggregating 550ft. The retaining walls of the approaches are of reinforced concrete, and the tunnel has a lining of the same material. The tunnel is 23ft. wide, with a height of 15ft. 7in. above the rails.

SOME interesting information regarding Turkish railways is contained in the annual report of Sir Adam Block on the Ottoman Public Debt. Since last year, the report states, the only railway which has progressed in construction is the Hamidie-Hedjaz line. Some 500 kiloms. of line have been built, and the total length of the railways now existing in Turkey amounts to about 6000 kiloms. The Hedjaz railway is fast approaching completion, the construction remaining to be completed before the line reaches Mecca being 600 kiloms. The Smyrna-Aiden Railway is about to construct 100 kiloms. of line to the Lake of Egirdir, and it is interesting to note that this, the only English railway in Turkey to-day, unlike a number of railways in the Ottoman Empire, has been successful.

IT is reported that, as the system of automatic signalling on the main line of the Metropolitan District Railway has been working successfully, the directors propose, from the beginning of 1908, to commence a new two-minute service. The directors are also making experiments in the running of express trains. For some time past morning expresses have been running from western stations to the City, and recently an evening train has been put on from the Mansion House at 5 44. After stopping at all stations to Victoria this has become express to West Kensington Recently another train, leaving at 5 14, was introduced, express from Victoria to Hammersmith. About six minutes are saved on each journey in this way, and it is hoped that by putting on these trains—more are to follow—new traffic from Ealing and Harrow and Hounslow, as well as West Kensington and Hammersmith, will be secured.

NOTES AND MEMORANDA.

DEPOSITS of bitumen are said to extend all along the coast of Venezuela from the Gulf of Paria to Colombia in the form of superficial lakes.

BY rubbing metals with salt before applying mercury the ancients obtained a reaction similar to that for which copper sulphate is used. The chlorine released from the salt formed a silver chloride easily attacked by the mercury, so as to form an amalgam.

IT has been proposed to use electro-magnets for lifting and handling large panes of glass. This is accomplished by placing a piece of sheet iron under the glass, and applying one or more electro-magnets on the upper face of the glass. The electro-magnets attract the sheet iron, and thereby hold the glass suspended while moving.

IN recent years, says a contemporary, researches have sufficiently established the position that meteoric irons may, in their essentials, be properly included in the category of steel; the fundamental difference being that, while artificially produced steels are mainly iron carbon alloys, meteoric iron steel is an iron nickel alloy with meteoric carbon.

WE believe that shingles are now made under a patented process from asbestos fibre and Portland cement. Owing to the enormous pressure under which the shingles are manufactured, it is said that they absorb, when fresh, only about 5 per cent. of their weight of water, and that when exposed to the atmosphere for a year or two hydration and subsequent crystallisation convert them into impermeable roof coverings.

IT is reported that at St. Stephen's, Grampround-road, Cornwall, there is a well-defined lode of uranium pitchblende, and it is stated by the miners that its radio activities are clearly perceptible in the dark after a blast. Contrary to the generally accepted theory that pitchblende is only to be found in shallow deposits in the district in question, it extends to a depth of thirty fathoms, becoming increasingly rich as it deepens.

THE United States Geological Survey reports the total value of the graphite produced in the United States in 1906 as £68,000, an increase of £4400 over the value of the 1905 output, but a decrease in quantity. The production included 5,887,982 lb. of crystalline graphite and 16,853 net tons of amorphous graphite, a decrease of 148,585 lb. of the former and of 5100 tons of the latter variety, as compared with 1905.

IN the "Proceedings" of the Edinburgh Mathematical Society Mr. R. F. Muirhead directs attention to a simple method of calculating first and second moments of certain elementary figures. By "second moments" are meant the same as "moments of inertia," the term being used to imply that the problem is not concerned with masses. The method in question, or one very similar to it, was known at Cambridge many years ago, but does not seem hitherto to have been much discussed.

MACHINE-MINED coal in the United States reached a total of 118,847,500 tons for 1906, which is 15 451,100 tons greater than in the previous year. There were 10 212 machines in use in 1906; of these 5911 were of the pick or puncher type; 4144 were chain-breast machines, and 157 were long-wall machines. The ratio of machine-mined tonnage to the total production in the States where machines were used has increased steadily each year, and in 1906 reached the high mark of 35·1 per cent.

IN a paper read before the Mannheim Bezirksverein the author draws attention to the large waste of power which is generally allowed to go on in testing prime movers of various types. This waste, he states, could easily be arrested by abandoning the use of absorption dynamometers and loading the prime mover under test by means of an asynchronous generator, which delivers power to the network supplying the works motors. Such a generator is very simple to deal with, as there are no commutator or paralleling troubles, and it furnishes an ideal brake.

MADAME CURIE announces, in the October number of *Le Radium*, the result of her re-determination of the atomic weight of radium under conditions much more favourable to accuracy than those which existed in 1902, when she had only 9 centigrams of chloride of radium on which to work. The present determination has been made with 4 decigrams by the method used in the former case, and gives as the result 225·2, if the atomic weight of silver be taken as 107·8. Madame Curie estimates the possible error of the determination as less than half a unit.

ACCORDING to the *Iron and Coal Trades Review*, a discovery of lignite has been made in the Knysna district, Cape Colony. A syndicate was formed to investigate the deposit, and on a shaft being sunk to a depth of 30ft. three seams of the mineral were struck, aggregating 17ft. in thickness Further tests were made at different places in the same district, and the area containing the lignite was found to be some miles in extent. Trials made with this fuel in Cape Town have given apparently satisfactory results, although, before the importance of the discovery can be fully estimated, experiments will have to be conducted on a larger scale.

AT Marlbank, in Ontario, four iron chimney stacks, each 60ft. high and 14ft. in diameter, lined inside with one thickness of fire-brick recently showed signs of corrosion in the plates. Instead of replacing with iron or steel it was decided to coat the outside of each stack with a 4in. layer of concrete. For this purpose a plate iron cylinder, 56in. in diameter and 48in. high, was used as a form and moved up the stack as the concrete, which was deposited within it, had set. Circumferential reinforcement of No. 7 wire was placed every vertical 6in. in the middle of the 4in. thickness. It is estimated that about £240 were saved in the construction by concrete covering above the cost of new iron or steel stacks.

PEAT coke manufacture by the Ziegler process has recently been started at Bauerberg, Bavaria. The peat is cut up, pressed, and exposed to the air until evaporation has reduced its water to less than 25 per cent. of the whole mass. This peat is then placed in a retort for eighteen hours. The coke is finally received in air-tight iron cars which are left for six or eight hours to cool before they are discharged. Each retort yields during every twenty-four hours eight to ten tons of coke. The gas is passed through various tanks and towers in which the by-products are separated, and is then employed in assisting the retort process which could not even commence without the external application of heat.

HITHERTO the operation of getting the boom defence into position at the entrance of the Hamoaze has been performed by manual labour, as well as the work of raising and lowering the gates of the defence. The latter has involved the employment of from thirty to fifty men, whose absence from their regular duties, especially in war time, might be severely felt. To obviate the necessity for this manual labour, the Admiralty have approved the installation of a vertical boiler and a powerful set of steam winches in each of the boom defence vessels, and a start is being made with the sloop Mariner, which has been placed in the basin at Keyham to enable the old propelling machinery and fittings to be removed, and to prepare her for the reception of the new appliances. It is calculated that by the aid of these fittings the ordinary staff of pensioners, slightly augmented, will be sufficient to handle the defence.

MISCELLANEA.

THE only cable connecting America with the Orient direct was put out of commission between Midway Island and Guam recently by an earthquake interrupting the communication.

THE Admiralty have decided to erect a large electricity station at Dover for power and lighting for the naval harbour. The contract for erecting the building has been secured by a Dover contractor.

IT is reported that a direct submarine cable from New York to Havana is to be laid for the Commercial Cable Company in order to reduce the time of transmission now necessary via the Florida route.

OFFICIAL information has been received that the Admiralty intend to proceed with the erection of a torpedo factory at Greenock. The site chosen is a field immediately adjoining Fort Matilda, and has already been marked off.

THE great electrical strike of workpeople of the Edison Company, which has kept Milan without trams for ten days, has ended with a total increase in wages to the men of £24,000. The Mayor of Milan will also arbitrate on lesser details.

THE Acting British Consul-General at Yokohama has forwarded a report on the subject of Government inspection of boilers in Japan, which may be consulted by British traders interested, at the Commercial Intelligence Branch of the Board of Trade.

THE Yarmouth Town Council proposes to replace nearly 800 gas lamps with a similar number of 64 candle-power electric lamps, the arc lighting of the town to be also extended A saving of £185 per annum is expected to result from the alterations, the cost of which will be nearly £2500.

WITH a depth at low water of 35ft. the new Ambrose channel out of New York harbour has been opened. The final depth is to be 40ft., and the further work is being carried on. The present depth, however, is such that the largest ocean liners may use the channel at nearly all stages of the tide.

A SUBSIDENCE occurred last Saturday on the main road leading from Willenhall, in South Staffordshire, to Short Heath. Two deep holes appeared on each side of the road, and all traffic had to be stopped and barricades erected. It is suggested that the subsidence has been caused by a subterranean fire.

THE Government of British Guiana has accepted the offer of the West India and Panama Telegraph Company to erect a system of wireless telegraphy between Georgetown, British Guiana, and Port of Spain, Trinidad, as a supplementary service to the present cable system, which is rendered very unreliable owing to the unsuitable nature of the sea bed between Trinidad and British Guiana.

IT has been stated that the battleship Dreadnought is giving excellent results with the new set of propeller blades with which she was fitted at Portsmouth. The vessel made a smart three-days' run from Glengariff to the "Rock," and it has been elicited that the pitch of the propeller blades accelerated the speed, with a normal coal expenditure. The new steering engine is also reported upon favourably.

THE police have again recently required a higher standard of condition for motor omnibuses presented to them for licensing, says *Motor Traction*, with the result that a comparatively large number has been rejected, and that great difficulty is being experienced with the operating omnibus companies to obtain licences for new cars. At the same time stop notices have become more frequent than has been the case for some months past.

AT the recent Miners' Conference in Manchester it was stated that Mr. H. Walker, of South Normanton, Derbyshire, had placed before the conference his invention giving a safe method of blasting in mines and quarries. This provides a means whereby a detonator can be placed in position in the explosive after the explosive is in the shot hole and has been rammed, and also the removal of the detonator if through any cause it misses fire.

ACCORDING to *The American Machinist*, the first attempt to establish iron and steel works in India has just been started by a rich firm in Bombay, supported by other wealthy individuals, and by the Government of India. The district in which the plant will be situated will be near Sini Junction on the Bengal Nagpur Railway, where there is abundance of water, and where iron ore, coal and limestone can be assembled at low cost of transit.

AT a meeting of the Commonwealth Cabinet on Tuesday, the Postmaster-General announced his decision to ask for tenders for wireless telegraphy plants at some half-dozen places round Australia. Tenderers are to sell their Australian rights to the Commonwealth. Parliament has decided not to allow, directly or indirectly, the establishment of a private monopoly The plants will be capable of receiving messages from passing steamers equipped with any of the recognised systems.

ACCORDING to the *Engineering News*, an amphibious automobile was successfully tried on November 13th on upper Riverside Drive, New York City, at Fort Washington Point on the Hudson River. The machine, or craft, resembles a narrow yawl, decked over fore and aft, with the exception of a cockpit for the pilot and a space for two passengers. It is 30ft. long, 6ft. beam, and about 3ft. 6in. deep amidships. When afloat it draws about 22in. of water. A De Dion two-cylinder 20 horse-power petrol engine furnishes the power, which may be applied to propeller or wheels at will. The wheels are of wood, plated with thin steel, and have hard rubber tires.

A WRITER in a contemporary states that he examined the envelope of a balloon which burst at the International Exhibition at Milan in 1906. A number of spots were visible on the envelope, and at these places the material could be easily torn, whereas at other parts it showed great resistance to tearing. These spots were found to have been caused by phosphoric and arsenic acids, produced by oxidation from arseniuretted and phosphoretted hydrogen contained in the hydrogen gas. The presence of these impurities is due to the use of impure materials in the preparation of the hydrogen, and the author recommends that the preparation of the gas for filling balloons should be under strict chemical control.

AUSTRIAN motorists are watching with much interest a project which promises to provide efficient repair shops and skilled workmen for making automobile repairs throughout the country districts, facilities which have hitherto been sadly lacking outside of the cities and towns. The Auto Technical Association is organising a training school for automobile repair work in the rooms of the Handicrafts Exhibition. It is especially intended for country blacksmiths, locksmiths, and other mechanics with a knowledge of machinery, and besides helping to provide automobile repair shops in country places the school will open up a new means of livelihood to these workmen, many of whom have lost a good deal of their original business through the introduction of the motor car The school will be completely equipped with tools and all requisites for the work of repairing cars. The course of instruction will last four weeks. Special provision will be made for the admission of workmen in poor circumstances by the grant of a small pecuniary compensation for the time spent in the school.

TWO NEW COLLIERY PUMPS

(For description see page 577)

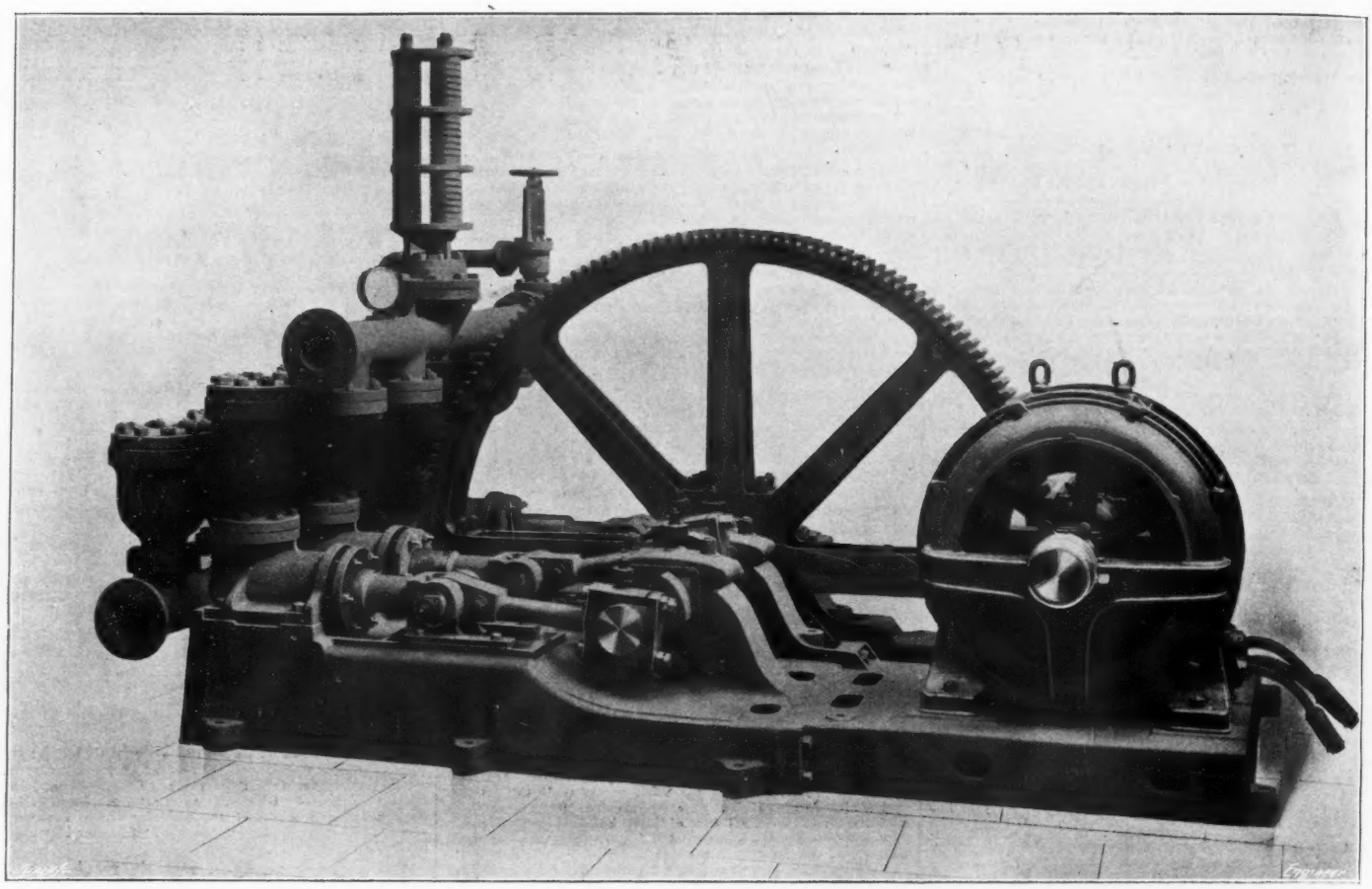


Fig. 1—THREE-THROW MOTOR DRIVEN PUMP

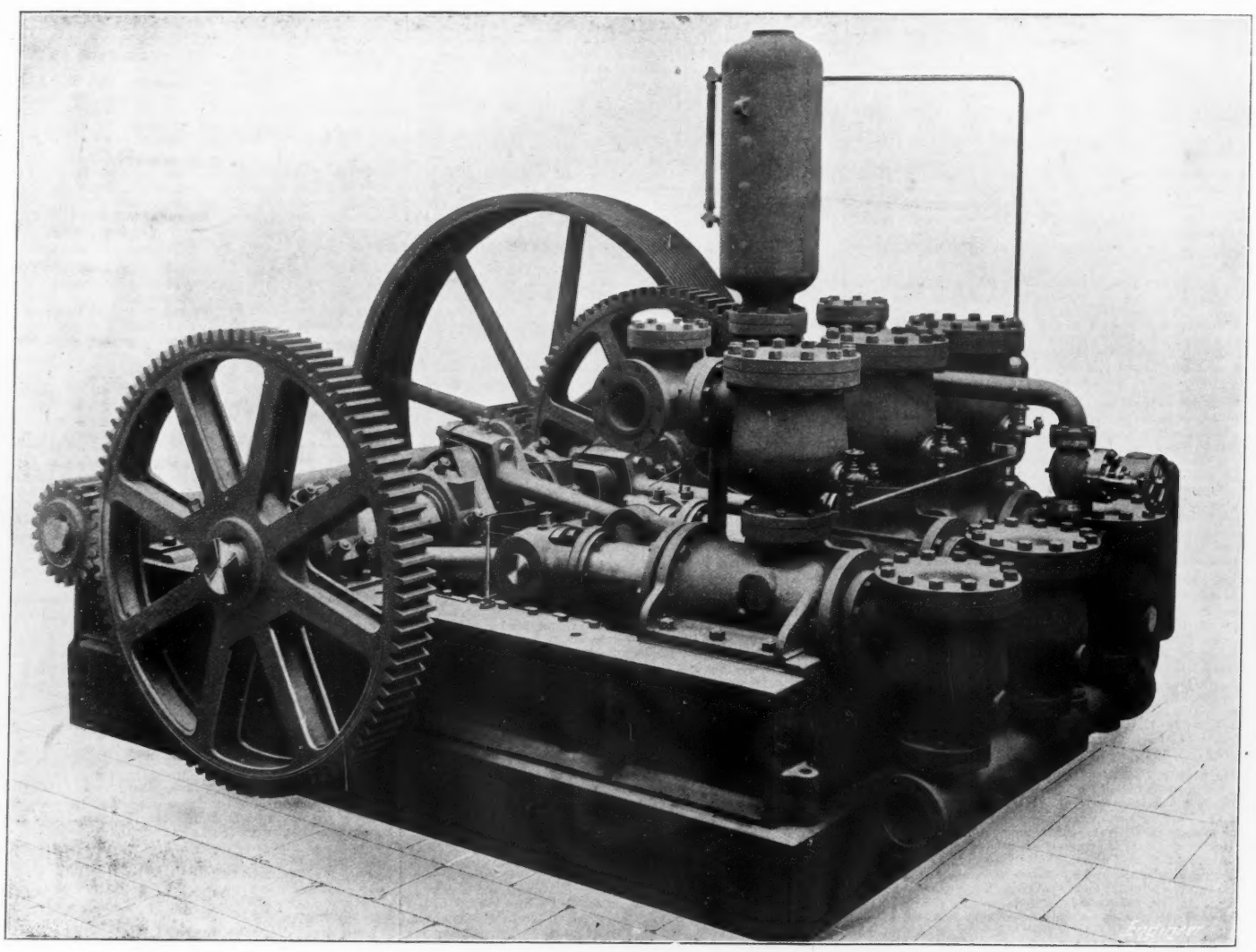


Fig. 2—THREE-THROW PUMP DRIVEN BY COTTON ROPES

FOREIGN AGENTS FOR SALE OF THE ENGINEER.

AUSTRIA.—F. A. BROCKHAUS, *Seilergasse 4, Vienna.*
CHINA.—KELLY AND WALSH, LIMITED, *Shanghai and Hong Kong.*
EGYPT.—F. DIEMER, FINCK & BEYLAENDER, *Shepheard's-buildings, Cairo.*
FRANCE.—BOYVEAU & CHEVILLET, *Rue de la Banque, Paris.*
CHAPELOT & CIE., *Rue Dauphine, 30, Paris*
GERMANY.—ASHER AND CO., 5, *Unter den Linden, Berlin.*
F. A. BROCKHAUS, *Leipsic;* A. TWEITMEYER, *Leipsic.*
INDIA.—A. J. COMBRIDGE AND CO., *Railway Bookstalls, Bombay.*
ITALY.—LOESCHER AND CO., 307, *Corso, Rome;* BOCCA FRERES, *Turin;*
ULRICO HOEPLI, *Milan.*
JAPAN.—KELLY AND WALSH, LIMITED, *Yokohama.*
Z. P. MARUYA AND CO., *Tokyo and Yokohama.*
RUSSIA.—C. RICKER, 14, *Nevsky Prospect, St. Petersburg.*
UNITED STATES OF AMERICA.—INTERNATIONAL NEWS CO., 83 *and* 85, *Duane-street, New York;* SUBSCRIPTION NEWS CO., *Chicago.*
S. AFRICA.—WM. DAWSON & SONS, LIMITED, 7, *Sea-st. (Box* 489), *Capetown.*
CENTRAL NEWS AGENCY, LIMITED, *Johannesburg, Capetown, Durban, &c., and at all their Bookstalls.*
J. C. JUTA AND CO., *Capetown, Port Elizabeth, Johannesburg, East London, Grahamstown.*
AUSTRALIA.—GORDON AND GOTCH, *Melbourne, Sydney, and Queen-street, Brisbane, &c.*
MELVILLE AND MULLEN, *Melbourne.*
TURNER AND HENDERSON, *Hunt-street, Sydney.*
NEW ZEALAND.—GORDON AND GOTCH, *Cuba-street Extension, Wellington, and Bedford-road, Christchurch.*
UPTON AND CO., *Auckland;* CRAIG, J. W., *Napier.*
CANADA.—MONTREAL NEWS CO., 386 *and* 388, *St. James-street, Montreal*
TORONTO NEWS CO., 42, *Yonge-street, Toronto.*
CEYLON.—WIJAYARTNA AND CO., *Colombo.*
JAMAICA.—SOLLES AND COCKING, *Kingston.*
STRAITS SETTLEMENTS.—KELLY AND WALSH, LIMITED, *Singapore.*

Subscriptions received at all the Post-offices on the Continent.

SUBSCRIPTIONS.

THE ENGINEER can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office on the following terms (paid in advance):—

Half-yearly (including double number) .. .. £0 14s. 6d.
Yearly (including two double numbers) .. .. £1 9s. 0d.

CLOTH READING CASES, to hold six issues, 2s. 6d. each, post free 2s. 10d.

If credit occur, an extra charge of two shillings and sixpence per annum will be made.

Foreign Subscriptions will, until further notice, be received at the rates given below. Foreign Subscribers paying in advance at these rates will receive THE ENGINEER weekly and post free. Subscriptions sent by Post-office Order must be made payable to THE ENGINEER, and accompanied by letter of advice to the Publisher.

THIN PAPER COPIES.		THICK PAPER COPIES.	
Half-yearly	£0 18s. 0d.	Half-yearly	£1 0s. 3d.
Yearly	£1 16s. 0d.	Yearly	£2 0s. 6d.

(The difference to cover extra postage)

ADVERTISEMENTS.

☞ The charge for advertisements of four lines and under is three shillings, for every two lines afterwards one shilling and sixpence; odd lines are charged one shilling. The line averages seven words. When an advertisement measures an inch or more, the charge is 10s. per inch. All single advertisements from the country must be accompanied by a Post-office Order in payment. Alternate advertisements will be inserted with all practical regularity, but regularity cannot be guaranteed in any such case. All except weekly advertisements are taken subject to this condition.

Advertisements cannot be inserted unless delivered before Five o'clock on Thursday evening, and in consequence of the necessity for going to press early with a portion of the edition ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week.

etters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

Telegraphic Address, "ENGINEER NEWSPAPER, LONDON." Telephone—No. 13352 Central.

PUBLISHER'S NOTICE.

*** *If any subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the Paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

CONTENTS.

THE ENGINEER, 6th December, 1907.

	PAGE
NOVEMBER	559
RIFLED ARTILLERY. No. III.	561
THE APPLICATION OF HIGHLY SUPERHEATED STEAM TO LOCOMOTIVES	562
THE FUTURE WATER SUPPLY OF LONDON. No. II	564
A PORTABLE ENGINE WITH SUPERHEATER. (Illustrated.)	566
A THOUSAND TONS A DAY	566
THE FRANCO-BRITISH EXHIBITION. No II. (Illustrated.)	567
FLOATING DOCK AT ROTTERDAM. (Illustrated.)	568
A NEW FLAME ARC LAMP. (Illustrated.)	570
METROPOLITAN RAILWAY PENSION FUND	570
NAVAL ENGINEER APPOINTMENTS	570
RAILWAY MATTERS	571
NOTES AND MEMORANDA	571
MISCELLANEA	571
LEADING ARTICLES—The Indian Railway Strike	573
A Noteworthy Boiler Explosion—Swedish Iron Ore Exports	574
The Naval Base at Rosyth	575
THE GERMAN INSTITUTION OF NAVAL ARCHITECTS. No. II.	575
THE IRON INDUSTRIES IN ODESSA	576
OBITUARY	576
ELEVEN MONTHS' CLYDE SHIPBUILDING	576
H.M. DESTROYER GHURKA	576
ELECTRICALLY-DRIVEN COLLIERY PUMPS. (Illustrated.)	577
COMPOUND STEAM TRACTOR. (Illustrated.)	577
LETTERS TO THE EDITOR	578
A NEW TUBELESS SEMI-FLASH BOILER. (Illustrated.)	580
AN INSTRUMENT FOR TESTING HARDNESS. (Illustrated.)	580
LABOUR-SAVING DEVICES AT THE MINES OF THE NEW KLEINFONTEIN COMPANY, TRANSVAAL. (Illustrated.)	581
THE INSTITUTION OF CIVIL ENGINEERS	582
THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS	582
NOTES FROM LANCASHIRE	582
THE SHEFFIELD DISTRICT	583
NORTH OF ENGLAND	583
NOTES FROM SCOTLAND	584
WALES AND ADJOINING COUNTIES	584
AMERICAN NOTES	584
PERSONAL AND BUSINESS ANNOUNCEMENTS	584
LAUNCHES AND TRIAL TRIPS	584
NOTES FROM GERMANY	585
BRITISH PATENT SPECIFICATIONS. (Illustrated.)	585
SELECTED AMERICAN SPECIFICATIONS. (Illustrated)	586

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

JAPAN.—The correct title of the company is the Nippon Yusen Kaisha; the London address is 2, Fenchurch-avenue.

G. R. W.—The Simplon Tunnel was dealt with in our issues of 27th September, 1901; 20th June, 4th July, 1st, 22nd, and 29th August, 26th September, 31st October and 26th December, 1902; 9th and 16th January, 27th March, 21st August, and 11th September, 1903; 19th August 9th September, 7th, 21st, and 28th October, 18th November, and 9th December, 1904; 3rd March, 7th April, 12th May, 9th June, 18th December, 1905; and 18th January, 1906. There have been numerous other references, but the above are the principal articles.

A. V. (Bordeaux).—The standard wire gauge is a list of sizes expressing the diameter of wires, and is abbreviated to s.w.g. The different diameters are indicated by numbers only; thus, for example, No 1 s.w.g is ·3in. diameter No. 2 s.w.g. is ·276in. diameter, No. 10 is ·128, and so on, up to No. 50 s.w.g., which is ·0010in. diameter. You have a French wire gauge, but it is different from ours; No. 1 being ·45 mm and No 22 being 0·80 mm. Our wire gauge is also used largely to express the thickness of thin plates. It is necessary to state standard wire gauge, as several others, Birmingham, Whitworth, &c., are in use.

INQUIRIES.

SALT REFINING PLANT.

SIR,—Can any of your readers inform me where I can obtain salt refining plant?
T. W.
December 3rd.

ERRATUM.

In our issue of November 29th page 546, column two, line six, for "in addition to" read "inclusive of."

MEETINGS NEXT WEEK.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, December 9th, at 8 p.m. Paper, "Types of Water-tube Boilers," by Mr R. J. P. Briggs.

THE INSTITUTION OF ELECTRICAL ENGINEERS: GLASGOW LOCAL SECTION.—Tuesday December 10th, at 8 p.m. By the courtesy of Prof. Archibald Barr and Prof. Andrew Grey members are invited to inspect the James Watt and Physical Laboratories at the Glasgow University.

CLEVELAND INSTITUTION OF ENGINEERS.—Monday, December 9th, at 7.30 p.m., in the Hall of the Cleveland Literary and Philosophical Society, Corporation-road, Middlesbrough. Paper, "Limitation to Economy in the use of Electric Driving," by MR. R. J. Worth, Stockton.

THE SOCIETY OF ROAD TRACTION ENGINEERS.—Tuesday, December 10th at 8 p.m., at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. Paper, "The Management, Organisation, and Cost of Working a Public Service Garage," by Mr. W. E. Hardy, A.M.I.E.E.

INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, December 11th, at 7.30 p.m., in the Large Lecture Theatre, The University, Edmund-street. Ordinary general meeting. Paper "The Torque Conditions in Alternate-current Motors," by Val. A. Fynn.

THE INSTITUTION OF CIVIL ENGINEERS: ASSOCIATION OF YORKSHIRE STUDENTS.—This evening, Friday, December 6th, at 7.30 p.m., in the Library, Philosophical Hall, Leeds. Ordinary meeting Paper, "The North Sewage Disposal Works of the Harrogate Corporation," by Mr. E. Wilson Dixon.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 10th, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Paper, "The Predetermination of Train Resistance," by Charles Ashley Carus-Wilson, M.A., Assoc.M.Inst.C.E. Wednesday, December 11th Students' visit to the Motor Works of Messrs. Clement Talbot, Limited, Barlby road, North Kensington, W.

THE JUNIOR INSTITUTION OF ENGINEERS.—Tuesday, December 10th, at 8 p.m., at the Society of Arts, John-street, Adelphi, W.C. Paper, "Arc Lighting," by Mr. William Krause. Saturday, December 14th, at 3 p.m. Visit the Franco-British Exhibition Buildings &c., the Exhibition Extension Works of the Central London Railway, and Central London Railway Power-house at Shepherd's Bush.

SOCIETY OF ARTS.—Monday, December 9th, at 8 p.m., at John-street, Adelphi, London W.C. Cantor Lectures: "The Theory of the Microscope," by Conrad Beck, F.R.M.S. Wednesday, December 11th, at 8 p.m. Ordinary meeting Alfred Lecture: "Radio-active Phenomena," by Sir William Ramsay, K.C.B., Ph.D., LL.D. Sc.D., F.R.S. Thursday, December 12th, at 4.30 p.m. Indian Section. "Big Game in India, by Reginald Gilbert, F.Z.S. late of Bombay. Friday, December 13th, at 8 p.m. Shaw Lecture on Industrial Hygiene: "Inoustrial Poisons, Lead and Phosphorus, with special reference to Lucifer Match Making," by Professor Thomas Oliver, M.D.

THE ENGINEER.

DECEMBER 6, 1907.

The Indian Railway Strike.

IN the attempt to eradicate a distemper the first endeavour is obviously a correct diagnosis, and India, which is now beginning to experience the discomforts and loss involved in labour disputes that threaten and sometimes culminate in strikes, should look to it and probe at the root of the evil lest the mischief take hold and reach the acute stage when remedies fail and the disease becomes chronic.

In England and on the Continent and in highly civilised countries generally these disputes have long since deserted the arena in which concrete cases of discord between employers and employed were discussed, and have shifted to the political platform. Capital and labour being essentially antagonistic—the former naturally endeavouring to buy in the cheapest market what the latter strives to sell in the dearest—the relative conditions are irreducible, and can only be met by a compromise And at best a compromise can be but a provisional compact, owing to restlessness in the price of both money and energy, so, at best, capital may be expected, in the task of holding its own, to yield in a measure to the representations made on grounds of fairness or humanity by the Labour protectionists, and the Labour—in its turn—will hesitate to stretch legislation and trades union agitation in its own favour to the point of alienating the capitalist. The British workman having withdrawn his individuality from the fight and handed over his case to his political representatives, the war is waged by professionals, and though decisive battles may be fought here and there, and lost or won by the assailants as the case may be, the campaign can never hope to reach a termination. How effectually the individual has been absorbed in this contest is evidenced by the report that in the recent ballot, during the threatened railway strike, many of Mr. Bell's adherents who voted for extreme measures had no ultimate intention whatever of going out. The effect was to render Mr. Lloyd-George's self-imposed task a comparatively speaking passive operation by hypnotic suggestion rather than a bold and determined routing of the enemy. No one will, of course, be disposed just now to quarrel with the Board of Trade chief for achieving his victory after his own fashion—for the victory is everything—but opiates have a way of evaporating, and those who hold that neutrality for seven years is now assured are possibly over-sanguine. A more emphatic authoritative protest would have possibly inspired more confidence in lasting results. Granting the abstract right of individuals or of even large bodies of men to strike, when it comes to paralysing the whole kingdom by a general railway suspension the question surely merits promotion to the rank of a national problem, and the public have a fair claim to protection by Government in the shape of an exercise of constitutional authority in the maintenance of law and order. Such national coercion would, by bearing the stamp of dignity, have appealed to all classes not blinded by passion in the dispute, and would, moreover, have established the precept that the responsibility of fomenting disputes of this magnitude to the verge of a disturbance of public interests must rest with the political agitators who hold such briefs, briefs no longer to be held with impunity in all conceivable cases.

It has seemed necessary to refer to conditions obtaining in England before approaching the Indian question, because the strike on the East Indian Railway, following as it did close on the heels of Mr. Bell's agitation, found the public mind in this country attuned to the circumstances governing the local trouble, and scarcely free to examine the Indian problem purely on its own merits. That the excitement displayed by the home Press may have induced a reflex action in India and emboldened the insubordinate railway staff is, of course, possible, and even probable, and the suddenness of the outburst in that country, and the unpreparedness of the railway authorities to meet it, may give colour to the suspicion of secret political influence from home expressed in some quarters; but, as a matter of fact, both these elements, if operative at the same time, may be regarded as purely incidental, and not representing a permanent factor in the question of Indian railway strikes generally. It is this contrast between the conditions governing defection in India and England which renders, or has hitherto rendered, the problem much less complex in the East. Whereas anything approaching finality in the matter of a mutual understanding between employers and employed appears in this country to have been deliberately excluded by the action of railway servants in throwing in their lot with "Labour" in its sempiternal struggle with "Capital," in India the railway subordinate is, as a matter of fact, not only an exceedingly hard worker—like his prototype in England—but he is an exceedingly loyal servant as well This is brought about by the fierce competition for *Sirkar's* service—the supply being vastly in excess of the demand—and the prestige attaching to permanent salaried service under the State or the great railway companies standing high in the estimation of the more or less educated outsiders who have failed to secure such appointments. The store of latent native talent to be drawn on is too vast even to permit of railway servants bettering their position except by appeals to their employers, and there is no possibility of sustained combination on anything approaching the lines on which European unions have been built up; an attempted coalition of Europeans, Eurasians, Hindus, and Mahomedans could never depend on the staunchness of all members of the society, nor on their continued loyalty to the cause. The so-called Amalgamated Society's barren history goes to prove this. The men realise this fully, and the consequence is that railway strikes have all been spasmodic and hysterical and of short duration, as are occasional strikes in the Bombay and Calcutta cotton and other mills.

Such being the relative positions of master and

man, it would at first sight appear that railway administrations may complacently regard these upheavals as temporary inconveniences, to be met each on its own merits. But there is danger lurking in this policy; it is not the strikes themselves that are to be feared, for they can be dealt with summarily; it is the inefficiency, the result of apathy induced by want of sympathy, that has to be guarded against. The staff may be powerless to coerce managers or agents owing to the keenness of competition, but they are, nevertheless, powerful for good and evil in their daily working, and it does not take much perspicacity to realise that a contented and loyal staff boasts a very real and tangible market value. In short, what the railway administrations should bear in mind is that their interests and those of the staff are in a great measure identical. The closest attention is therefore due to the welfare of the servants, and this has not been invariably a feature in railway management in the past. The temptation is great to make use of the competition which tends to cheapen railway labour—because the ultimate effect is beyond the immediate range of vision—but a far-sighted policy would not blind itself to remoter consequences. Managements jealously guard against enhanced working expenses, and rightly so, seeing that boards of directors look to dividends; but facts must be faced sooner or later, and the sooner the better for the ultimate benefit of railways—a possible temporary drop in dividends notwithstanding. No permanent loss need be anticipated—good working means good returns and economy in all branches. Indian railway servants are, generally speaking, underpaid considering their ever-growing responsibilities; they are sometimes overworked, and often denied quarters or barracks—having to shift for themselves in insanitary bazaars—often suffer interrupted sequence of employment as traffic fluctuates, and their provident funds are inadequate. Subject to heavy fines for breaches of rules, salaries should be commensurate with the difficulties involved in guarding against breaches—for practical railway men know full well how hard it often is to push through the work with despatch while adhering strictly to the rules and regulations. Stationmasters, now mostly natives, are often paid abnormally low wages, and it is to be feared that the administrations in some cases—who would, however, indignantly deny the charge—subconsciously accept in justification the prevalence of that irrepressible native vice which so frequently adds to the bare emoluments officially recognised. That a mere rise in salaries would eradicate this vice is too much to hope, but that inadequate remuneration fosters it is undeniable. A severe screening out of the incompetent should be the complement in the bargain for better pay. Such eclecticism would, perhaps, not be generally popular in a country where permanent employment once obtained is regarded almost as a sacred right, but the able, energetic, and zealous members of the staff would fearlessly face this vigorous selection as the price of substantial recognition. As regards hours of labour, the running staff require protection against their own instincts in the accumulation of "overtime"; the popularity of this method of payment, as affording remuneration in direct ratio to effort, renders it a convenient system, but obviously it requires careful circumscription by the authorities. The difficulty lies in meeting periods of spasmodic pressure of traffic. If extra hands are then taken on they have to be disbanded when the boom is over, giving rise to one of the most serious disadvantages of which the men complain, namely, uncertainty of employment. Probably some carefully planned system of retaining "understudies" would help to mitigate the evil; on most lines, for instance, firemen understudy drivers, and are, on emergencies, replaced by coolies. The principle might be extended. The housing of the staff is a very important matter, and many Indian railways are behindhand in this respect. The whole of the running staff have a fair title to official quarters, as have also such of the station and workshop staff whose services involve a sudden call to duty at all hours. The poverty of the Provident funds has been frequently brought to notice. On State railways the funds were ostensibly designed to replace the pension system by affording to the recipients a stimulus to exertion by direct participation in profits, but the funds have failed in practice to approximate to pensions in the adequacy of provision for beneficiaries. As men on both systems work side by side discontent is bred. The funds stand in need of actuarial overhaul, with a dash of generosity as seasoning. The guaranteed companies' funds are constructed more or less on lines parallel with those of Government railways, and are open to the same objection. There are, in fact, many substantial grievances, but none which sympathetic management cannot redress. The initial cost will be considerable, but the aggregate returns of *all* Indian railways—including many miles of strategic lines which earn barely their working expenses—according to the last published statistics, yield nearly 6 per cent. on the total capital outlay, and this magnificent revenue—due largely to improved mechanical methods and appliances, which by multiplying trains numerically, by raising speed and by accelerating the despatch of business, have thrown greater responsibilities on the staff—can well afford to relinquish a rational proportionate share in favour of the workers. Such a policy will, moreover, pay in the long run.

Finally, the lesson to be learned from the recent strike on the East Indian is two-fold. First, there must be no parleying with defectionists: the State has the power to suppress insubordination without unduly severe measures, and should do so unhesitatingly, for the smallest loss of prestige on the part of the Government of India has a most baneful and demoralising effect on the country generally. Secondly, it follows from the circumstances above described, that no Board of "Conciliation" is required, but that the highly efficient and experienced railway officers in India should be given a free hand to set their house in order, and be cautioned not to wait until strikes bring grievances prominently to notice—a policy unworthy the dignity of rich and powerful railway administrations. If this be undertaken now, whilst the labour question has not yet assumed political importance, we shall hear no more of combined opposition; if, on the other hand, the rents are merely patched by arbitration the trouble will become chronic.

A Noteworthy Boiler Explosion.

A VIOLENT explosion of the boiler of a railway locomotive is so rare an event that its occurrence always deserves particular attention. Many boilers of the type are, of course, used to supply steam to stationary engines; then there are portable and traction engines, all of which explode now and then. But the boilers in use on our railways are *sui generis*. They have special features in their design inseparable from the stringent conditions under which they work, and they are so well made and so carefully looked after that the idea of a catastrophe is never associated with them. For this reason a Board of Trade report just issued possesses exceptional interest.

On the 25th of September, about 3 a.m., the fire-box of a six coupled goods engine, while standing in the goods siding at Wath Station on the Hull and Barnsley Railway, collapsed. The fireman had gone to the signal-box. There was no one near the engine but the driver who was blown off the footplate, and died soon afterwards. The facts of the explosion are simple enough, but there were antecedent circumstances which require some elucidation. It was a tank engine with six wheels coupled, and a radial trailing axle. The exterior shell plates were made of steel, and the fire-box of copper. The mean diameter of the barrel was 4ft. 1⅞in., the length 10ft., and the plates $\frac{9}{16}$in. thick. The fire-box was 4ft 9¾in. long, 3ft. 4½in. wide, 5ft. 4in. high at the back end, and 5ft. 9in. at the forward end, all inside dimensions. The plate forming the top and sides was ½in. thick, the tube plate, where perforated for the tubes, $\frac{13}{16}$in. thick, reduced to ½in. at the lower part; the back plate was ⅝in. thick. The water spaces at the sides and ends were, according to the report, 3in. wide, the stays supporting these parts being $\frac{15}{16}$in. diameter, and approximately 4in. pitch. The crown plate was supported by twelve transverse rows of stays, nine of which were attached to the shell plate, the three forward rows being screwed into cross girders, the ends of which were supported on short angle bars riveted to the outer shell plate. We are told that the safety valves were loaded to 150 lb. The evidence, however, was to the effect that the original load had been 170 lb., and this had been reduced to 160 lb. It will be seen that the water legs were very deep, and they were quite parallel up to the level of the middle row of tubes, from which point the external fire-box took the curve of the barrel of the boiler, with which it was flush. It appears to us that a somewhat important error has been made in taking these measurements. For the 4ft. 8½in. gauge the normal distance between the main frames is 4ft. 1in. Occasionally the clearance between the wheels and the frames is slightly diminished, but the amount to be had in this way is insignificant. The outside width, then, of the fire-box shell, even if we suppose it to have been a very close fit sideways in the frames, could not have exceeded 48in. The thickness of the outer fire-box plates was a fraction over half an inch. Adding all four thicknesses we have a little over 2in., which, deducted from 48in., leaves 46in. But the width of the fire-box inside is given as 40½in. This leaves at the most not 3in. but 2¾in. for the width of the water spaces. There is therefore, we think, reason to assume that the water space was only 2½in., instead of 3in. Now, every fraction of an inch of extra width that can be given to a water space is of importance, and under no circumstances should it be less than 4in. The engine was comparatively new, having been built in 1901. According to the official report, the explosion resulted from the failure of a group of stays, about thirty in number, situated near the bottom of the fire-box on the left-hand side. The riveted overheads of these stays were quite worn away. The inside box was blown in—with an exception mentioned below—and the outside box blown out. It is unnecessary to reproduce the theory of the sequence of events given in the official report, which, indeed, is not quite intelligible in some respects; as, for example, the statement that the side of the copper fire-box was "blown to the left-hand side of the boiler, its flight in that direction being due to the bottom edge remaining attached to the foundation ring to the last." Why it should go out through the sides of the box we do not know, nor is it stated how it escaped the side frames. In order to understand why the stays failed we must say something of the history of the boiler. In 1905 it was sent to the repair shops for a thorough overhaul. From that date onward we have a nearly continuous record of troubles. Stays broke within a few months after the engine left the repair shops. Thus, in December, 1906, as many as forty-one stays had to be replaced. Then there was much leakage. According to the official report, speaking of the group of stays which gave way as mentioned above. "The attachment of these to the copper plate had become most defective. The clenched heads of these stays were completely wasted away, and this part of the fire-box side was in consequence dependent for support on the screwed part of the stays in the stay holes; but owing to the repeated hammering and caulking of the ends to make them steam tight the threads had been seriously damaged, and the stays had become too short, the ends being below the fire surface of the plate." Another fact of some significance is that the boiler seems to have had a reputation for steaming badly. The unfortunate driver told a shunter just before the explosion that he could not take more than twenty wagons, the regular load being twenty-six wagons. The fireman stated that they had trouble all day for want of steam; why, he did not know.

Now, in a properly designed and properly worked locomotive boiler, although stays fail and leak, there are no troubles with them such as were catalogued by the locomotive foreman of the district. To all intents and purposes the case was exceptional, and it is quite desirable that it should be much more fully investigated than it was. Thus not one word was said about the condition of the fire-box plates as regards incrustation, or the nature of the water used in the district. The symptoms go to show that the plates and the ends of the stays were repeatedly overheated. This could only occur if the circulation was deficient or the surfaces dirty. The engine may have been overworked, and sufficient time for cleaning and overhauling in the running shed not allowed. This hypothesis is strengthened by the circumstance that the boilermaker who had caulked the stays reported more than once to the foreman that the engine needed careful overhauling; and that he was told that the moment another engine was ready to take its place this locomotive would be sent to the shops. According to Mr. Carlton, who reported to Colonel von Donop, the whole fire-box was in a ruinous condition. "The number of old broken and partly broken stays had become a matter of serious moment, but the explosion did not occur in consequence of these." It is impossible to dissent from his verdict "that a serious error of judgment was committed in continuing to work the engine without having the stays renewed."

Quite apart from this aspect of the question remains one of much more interest to engineers. Beyond doubt the rapid destruction of stays in this boiler was exceptional. They were rather too small, being under an inch in diameter. They were, no doubt, of the very best copper, but, unfortunately, the best copper is often found to be far too soft for fire-box work, and the riveted heads are rapidly worn away by the attrition of the fire. Much more might be written; possibly we have said enough to elicit some further information, particularly as to the behaviour of copper of various qualities in locomotive fire-boxes.

Swedish Iron Ore Exports.

THE problem of the regulation or restriction of the future exports of iron ore from Sweden has

now apparently been divested of most of its uncertainties by the fresh light which has just been thrown on the question. The peculiar situation which has existed for several months past has arisen in connection with the partial nationalisation of the most important iron ore mines in Sweden, to which reference was made in these columns on April 19th, 1907. It is merely necessary to recall the fact that a Government Bill, which was under consideration at that time and was subsequently passed into law, transferred to the State the ownership of various mines in the Norrland, with the exception of the important mines of Luossovaara-Kürunavaara and Gellivare. The Act, however, authorised the consolidation of these latter mines, which furnish a quantity of ore for British blast furnaces, in the hands of the Kiruna Company, whose share capital was increased to approximately £4,400,000 for this purpose. One-half of this sum is represented by ordinary share capital, and is held partly by the Gellivare Company and partly by the Grangesberg Traffic Company; whilst the other half is composed of preference shares which have been handed over to the Government in return for the so-called surrender of the State mining rights over the iron ore fields of Luossovaara, Kürunavaara, and Gellivare. These rights, it would appear, would entitle the State, as the owner of the land, to one-half of the working results. Apart from certain legal questions which might have arisen if the amalgamation had not taken place, the exact bearing which this alleged relinquishment of State rights over these particular ore fields has upon the problem is not quite obvious, seeing that, in addition to the possession in preference shares of one-half of the share capital, the State has the right of purchasing in 1932 the whole of the ordinary shares on terms which have already been arranged. The exercise of this privilege by the Government of the day would place the entire property in the hands of the State in that year, or in 1937 if an extension of time were desired by the Government.

The misapprehensions which have arisen in respect of the agreements between the Government and the companies concerned centre around the exportation of ore, and have been entertained both in Great Britain and Germany, the latter of which is the largest consumer of Swedish ore. It has been thought that in the desire to promote the native iron and steel industry the Government of Sweden would seek to hamper the iron ore export trade in some way or other, and that if an export duty were not levied, as has been suggested on various occasions in recent years, the equivalent of such an impost would be found by means of an inland tax, or by charging higher railway rates for the transport of ore to the frontier or port of shipment. These ideas appear, however, to have no solid foundation, judging from recent information on the subject, which is now confirmed by *Stahl und Eisen*. On one point there has not been any difference of opinion, namely, that a limit has been placed upon the export of ore from the mines under consideration during the twenty-five years ending with 1932. The limit which will be gradually reached amounts to a maximum of 4,000,000 tons of ore per annum, and with the exception of orders which have still to be completed, the exports will be exclusively composed of phosphoric ores, leaving the material nearly free from phosphorus for the use of inland consumers. As to the imposition of an export duty, we pointed out some time ago that this is precluded by the terms of the commercial treaty between Sweden and Germany, which extends until the end of 1912. The expiration of the treaty would, of course, render it possible for the levying of such a duty, but it turns out that provision for such a contingency has already been made in the agreements between the Government of Sweden and the companies, and been endorsed by the Act passed by the Parliament. The arrangement is to the effect that in the event of an export duty being imposed the Government will financially compensate the companies for any losses thereby sustained. This being the case, there would be no object in proposing a duty, but if such a charge were made, and then refunded by way of compensation, this should not in itself cause the price of ore to advance in 1913. The agreements also fix the railway rates for the carriage of ore, and this practically settles the cost of transport during the period of the arrangements which are now in force. The only consideration remaining is that of an inland tax on the production of ore. A tax of this kind has, in fact, been arranged in the agreements in consideration of the Government absolutely relinquishing claims to any dividend on the preference shares down to 1937, the rate varying from about 3d. to slightly over 6d. per ton of ore until 1927, and rising to twice that amount in the final years.

The conclusion to be drawn from the latest phase of the Swedish iron ore question is that the outlook for foreign consumers, within the limits fixed by the Government in regard to the maximum tonnage of the exports, is not so unfavourable as has been imagined. In the first place, the supply of ore should not be rendered dearer by railway charges, as the rates are to remain the same; secondly, an export duty is not to be levied for several years, and if such an impost is then made the amount is to be returned, so that the position should be unchanged; and in the third place, the Government, instead of receiving a dividend on the preference capital, will be paid a fixed rate per ton according to the quantity of ore mined. But the iron ore mines controlled by the agreements under consideration by no means exhaust the resources available for drawing upon for the export trade, and it is in these directions that a further increase may be expected in the years to come. The extensive Svappavaara deposits and other sources of ore only require additional transport facilities in order to enable a considerable augmentation in the exports to be carried out. It is expected that the Svappavaara ore mines, which are being worked by a Swedish syndicate, will be able to place from 500,000 tons to 800,000 tons on the export market in a few years; and the Metallurgiska Aktiebolaget is believed to have a quantity of briquetted iron ore for export, whilst other companies are working in a similar direction. At the same time the fact that the Swedish Government has placed its hands upon the Norrland mines must of necessity cause a feeling of uncertainty to exist in the minds of consumers as to what State action may possibly be taken in respect of other mines in the future, and the increasing exports of ore from Sweden in recent years, notwithstanding the retrogression in the native consumption, will scarcely help to dispel this idea from those pig iron producers who avail themselves of this source of raw material.

The Naval Base at Rosyth.

AN announcement which Lord Tweedmouth, the First Lord of the Admiralty, made in the course of a speech at a social function at Duns, Berwickshire, on the 30th ult., is being accepted as an assurance that a work of great national urgency and importance is at last to be taken in hand in earnest. This, in brief, was an intimation of the Admiralty's determination to proceed with the new naval base at Rosyth on the Forth, and the statement that they were about to issue tenders for the undertaking. The base will include a basin of 56 acres, having a depth of 36ft. at all tides, and there will be accommodation at the quays for twenty-two warships, or, if double-banked, for forty-four. There will also be a dock of sufficient size to take the biggest battleships of modern times. The cost will, of course, be great, and the scheme will take ten years to complete; but Lord Tweedmouth believed it was an absolutely necessary addition to the naval equipment of the country. The necessity, he said, of building the enormous battleships of the present day had been more or less forced upon them, and there was not at present on the east seaboard of this country a dock sufficient to admit them, although on the Clyde, the Severn, the Mersey, and at Belfast there were private docks capable of taking them in, as well as Government docks at Portsmouth and Devonport. The base that had been chosen, he thought, was the right place. The Forth had a splendid railway communication, a good water supply, and was close to the shipbuilding facilities of Leith and Granton, and, in case of emergency, the best of shipwrights and engineers could readily be got from the Clyde. This authoritative announcement by the First Lord is of great importance generally, but specially so to the inhabitants of the towns on the Forth and the East Coast of Scotland, by whom it has been hailed with great satisfaction. Now that the establishment of the base is a certainty, a decided improvement may be looked for in trade generally, and tramways, buildings, and other projects which have been lying in abeyance, for the lack, mainly, of an authoritative intimation as to the Admiralty's intentions, will in all likelihood be started immediately. Further information of an authentic nature as to the development of the scheme is to the effect that the contractors, Messrs. Sir John Jackson, have decided to sink the test caisson another 15ft., the depth already attained being 90ft. The object of the additional sinking is to prove the depth of the boulder clay into which the cylinder has already been sunk. Even allowing for the probable future evolution in the dimensions and draught of naval ships, it would appear as if the Admiralty were making ample provision for the future in verifying the soundness of the foundations for walls, &c., by sinking to a depth of 105ft. Foundations at this depth would safeguard against dredging to attain a depth of water at low tide of between 40ft. and 50ft., and provide for a height of wall of between 20ft. and 30ft. above high-water level. Although the Admiralty and the Government have been either vacillating or reticent for a long time as to their designs at Rosyth, it is now apparent that what Lord Tweedmouth in making his announcement characterised as "an absolutely necessary addition to our naval establishment" is going to be a thoroughly efficient addition.

THE GERMAN INSTITUTION OF NAVAL ARCHITECTS.

No. II.*

THE paper by Herr Bauer, of which we gave an abstract last week, was followed by one on "Electrically Driven Propellers," contributed by Herr C. Schulthes, of Berlin, and was written in connection with Herr Bauer's paper. It gives a historical review of the development of the electrically driven screw propeller, and discusses in succession the various systems of which this forms a part. These are:—(1) Pure accumulator propulsion. (2) The Siemens-Schuckert combination system of explosion-motors in connection with accumulators. (3) The del Proposto system of explosion-motors with electro-motors on the same shaft for manœuvring. (4) Explosion-motors with pure electrical transmission of the power to the propeller. (5) Electric transmission of power from high-speed steam turbines to low-speed propellers.

Discussing these various systems, the author remarks that propulsion by means of accumulators, which for general purposes is prohibited by the weight of the latter, may under certain circumstances be expedient; for example, when a train of barges is escorted by a convoy boat which acts as a power station. The barges may have motors of their own, and current may be supplied to them by cable from the convoy boat. Designs have been prepared for a service of this kind, in which each barge can be driven by its own machinery for a distance of about 60 miles without its battery having to be recharged, and it is expected that the system will shortly be tried in practice.

An example of the combination system is given in the yacht Ellen, which has proved a great success. The installation consists of:—(1) The accumulator battery; (2) the starting and regulating apparatus; (3) the apparatus for charging from the shore; (4) the electro-motor; (5) two electric or mechanical couplings—one between the propeller and the electro-motor and the other between the electro-motor and the benzine motor; (6) the benzine motor, with appurtenances. The boat may be driven by the accumulators alone, or by the combined action of the benzine motor and the electro-motor. Two valuable qualities attaching to the electrical actuation of the propeller are the high efficiency of the latter, due to smoothness of running and the absence of all racing.

In the del Proposto system the installation consists of:—(1) The main motor, generally of the explosion type; (2) a dynamo; (3) an electro-motor; (4) a coupling, generally electric and disconnectable, between dynamo and motor; (5) the source of power for the excitation of the field magnets of the dynamo and of the motor—either the light dynamo or a special dynamo on the shafting; (6) the electric starting appliance. The advantages of the del Proposto system are in general much the same as those of the combination system above described. In many cases, however, the speed of revolution of the machinery may be higher than is desirable for the propeller, and electric transmission without the line of shafting may with advantage be resorted to. The combination system with battery enables extra power to be applied for a short time, which may often help a vessel over a difficulty. In addition, the reserve of power in the battery may be made use of for starting the explosion motor. For the Diesel motor a store of compressed air, or for other explosion motors a small battery, has to be provided for this purpose. An installation of this kind has the same parts as the del Proposto system above referred to, with the exception of the shafting and the coupling, which here fall away.

What has been said of the explosion-motor systems applies also to that of propulsion by steam turbines, which work economically at high speeds of revolution, while the screw propeller does so only at relatively low speeds. The adoption of electric transmission of power from the turbine to the propeller enables both these parts to work under the best conditions, and materially adds to the economy of the whole arrangement.

It is considered that the adoption of the principle of electric transmission will satisfactorily solve the turbine question.

The principal advantages of the electric transmission are:—(1) A reduction in the engine-room staff; (2) a simplification of working; (3) increased economy; (4) the impossibility of racing; (5) the possibility of actuating the propellers and rudder directly from the bridge.

In conclusion, the author confidently asserts that engineers are ready to provide such installations as soon as ever the shipowners ask them to do so.

The discussion on the papers of Messrs. Bauer and Schulthes was opened by Kommerzienrat Gotthard Sachsenberg, who spoke against the substitution of the turbo-electric and electromotor arrangements for the reciprocating engine in the paddle steamer. The greatest drawback to these, he said, was their weight. This feature was of peculiar importance in river steamers, the conditions in regard to it being so stringent that if the draught of the vessel were increased by $\frac{3}{4}$in. the builder might be subject to a not inconsiderable penalty, and if the excess amounted to from 12in. to 16in. he might have

* No. I. appeared November 29th.

the vessel thrown upon his hands. The actual weight of the engines and boilers—triple-expansion machinery—in the paddle tug steamer Kaiser Wilhelm II., for which the author of the paper had designed a turbo-electric installation, he (the speaker) gave as 56 tons, while the proposed arrangement weighed 110 tons, *i.e.*, almost twice as much. Further, the 60 revolutions given was too high a figure for paddle steamers. According to experience, from 30 to 45 revolutions were suitable. If the size of the engine room were, by the new arrangement, smaller than before, this was a matter of no great moment, for the draught fixed rendered necessary a certain size of vessel, which could afford abundance of room for the machinery. The same drawback showed itself in comparison with a compound engine of equal power. An engine of 1400 to 1450 E.H.P. actually constructed had weighed 72 tons, against the 110 tons of the arrangement proposed. The coal consumption, however, which the author puts at 0·9 kilos., amounted only to from 0·63 to 0·65 kilos. per I.H.P., or 0·78 kilos. per E.H.P. A saving in men the speaker also considered to be impossible, since this steamer had only one engineer and the number of stokers remained unaltered. The eventual application of water-tube boilers was also undesirable, since it would entail the fitting of surface condensers, which, again, would increase the weight. In connection with the condensing engine now made use of these boilers had not shown to advantage. They had in many cases been re-constructed or taken out altogether. Except as regarded the saving in oil, he did not see any advantage in the introduction of the turbo-electric plant, but only disadvantages.

The second speaker, Oberingenieur Techel, turned his attention to Herr Bauer's paper. Considerable thanks were, he considered, due to him for the simple graphic method he had given for determining the speed of revolution. This determination was very necessary indeed, for the case of the high-speed motor boats was very much like that of the high-speed turbines, of which no one could at first make anything. In order to make use of this method of Herr Bauer's, however, a large quantity of experimental data were necessary—especially such as related to pitch. Such curves were, however, already in existence, and had been published by Taylor in 1904 in one of the American papers. These included pitch ratios of 0·6 to 1·5. These curves of Taylor's were almost identical with those of Herr Bauer. A weak point in motors was, he said, the determination of the power by the troublesome method of brake experiments. It was possible, however, by the help of Taylor's experiments, approximately to determine the powers, although the method itself was not absolutely trustworthy. For high-speed motor boats it was of great importance to obtain the highest possible speed with a comparatively small engine. In general, Herr Bauer's results could not, he pointed out, be extended to large marine installations. In conclusion, the speaker objected to the definition of high-speed boats being applied only to such craft as ran distances equal to more than half their own length in a second. In order to comply with such a condition a torpedo boat, for instance, would have to run at more than 64 knots in order to merit the epithet "high-speed." Not the length, therefore, but the square root of the length would have to be taken as the unit.

Regierungsrat Martin considered it a very gratifying circumstance that the transport barges mentioned in the paper, which were built in the "Germania" and Cæsar Wollheim shipyards, had shown such exceptional fitness for their work, and such good carrying capacity. They required few men to work them; they were easily propelled at a speed which was sufficient for the purpose, while their electromotors took up very little room, worked very smoothly, and were very light. The only disadvantage, he said, was that in the light condition the barges were easily forced out of their course. Although a final judgment on the merits of the electromotor transport barges could not yet be given, it was to be hoped that this forward step in engineering would prove successful, and it was a matter for congratulation that the private shipmasters would thereby be emancipated from the rules of the steamship companies.

Professor Laas objected to the introduction of the electromotor into the motor machinery of sailing vessels. Although he fully recognised the advantages as regards reversing, the question of cost was in such cases all-important. Further, he said it was not necessary to fit a high-speed motor—the slowly-working Diesel motor could be applied. It was only required to get the vessel through the doldrums, and whether she was taken through these at 4 or 6 knots speed made little difference. By the introduction of the electromotor, however, the first cost of the machinery was increased by from 50 to 60 per cent. This question must, he said, be looked at from the point of view of the shipowner, and a profit and loss estimate in which the introduction of an electromotor showed a loss of M. 30,000 had better not be laid before him. In this calculation, however, two-thirds of the cost stood under the head of writings-off and one-third under that of expenses of working and materials used. In the speaker's opinion, the introduction of the electrical methods in a sailing vessel would first become a practical measure when all the auxiliary machinery was of the electrical description. and, in view of the sensitive nature of such machinery, this was, in the meantime, not to be thought of. His advice, then, was not to try this system, as the result of its application would only be an experimental vessel.

Herr Meissner stated that the naval boats of 15 knots speed and above, mentioned in the paper, had reversing screws, and that this was also the case in the Italian navy in boats of as much as 160 I.H.P. Whilst he thought the reversing motor was undoubtedly an ideal to be striven after, the development of the reversing propeller should also be considered.

Vice-Admiral Ahlefeld gave it as his opinion that the high-speed motor boats could with advantage be adopted for naval purposes, but that for these the values placed on their various qualities should be somewhat modified—that for speed, for instance, having been over-rated. For naval purposes the boats should, he considered, be valued according to the following scale:—(1) Reliability of the motor, 100; (2) sea qualities, 80; (3) facility of manœuvring the engine—*i.e.*, starting, going slowly, &c.—60; (4) speed, 50. In regard to the danger of explosion he took the opposite standpoint to that of the author of the paper. The chance of a shot striking did not come into the question at all.

Direktor Lasche, of the Allgemeine Elektrizitäts Gesellschaft, stated, in opposition to the view of the author, "that the performances of the turbine steamer Kaiser had been only moderately good;" that in the opinion of the builders the Kaiser was a complete success. For the main engines of a vessel no improvement could be effected by the introduction of electric transmission. This question, he said, had been carefully gone into by the Allgemeine Elektrizitäts Gesellschaft, the Stettiner Vulcan, and the Hamburg-Amerika-Linie, and had given an entirely negative result; in the case of this vessel, for instance, the weight would thereby have been increased from 120 tons to 240 tons, while the room necessary for the electro-motors could not be provided, and the cost would be very great without these disadvantages being balanced by advantages of any kind. The domains of application of the electric and turbine propellers respectively were, he considered, quite distinct from one another. Between these lay the reciprocating engine. Further, the Schlick gyroscope could not be combined with a turbine, since the introduction of the steam would be too difficult.

Another speaker, in opposing the views of the author, gave an instance in which a tugboat plying between Mayence and Mannheim was re-engined with turbine machinery, which was to develop the same towing power on the same coal consumption and the same draught as the original reciprocating engine. The result was, he said, an entire failure, and the turbine was, in its turn, replaced by a reciprocating engine.

In replying to the discussion, Herr Bauer first expressed his satisfaction at the position assumed by the naval authorities towards the motor boat question, and again endeavoured to allay the fears expressed in regard to the danger of explosion. In regard to Taylor's curves and the remarks of Herr Techel, he pointed out that the number of revolutions was in itself no criterion of the performance, but depended on the work required of the screw.

Direktor Schulthes in his reply laid stress upon the circumstance that the turbo-electric system of working was in a much higher degree capable of expansion than that of the reciprocating engine. He did not by any means underestimate the objection to increase of draught. It was self-evident that the weight of the whole plant must not be increased by the electrical additions. Referring to the introduction of electricity as an auxiliary power in sailing vessels, he expressed the opinion that recourse must be had to electric transmission in cases in which the motor could not be made available without such assistance. He expressed himself pleased to hear that the Vulcan and the Hamburg America Line were well satisfied with the Kaiser. His own observations, and the circumstance that no other similar vessel had yet been built, had led him to another conclusion. He then once more laid stress on the point that for ships and torpedo boats of very high speed and for small craft with less than 1000 indicated horse-power the system of electric transmission of power was not applicable, but that it was suitable for vessels of low speed. He had only alluded to the Schlick gyroscope in order to complete his work. He did not by any means overlook the very great difficulty of the introduction of the steam.

THE IRON INDUSTRIES IN ODESSA.

(*By our own Correspondent.*)

In common with nearly every industry the iron and steel trades in Odessa and throughout South Russia generally have suffered greatly from the disturbed conditions of the past two years. Business is almost at a standstill. Capital is leaving the country and there is no enterprise. Factories are running on half time, and in the engineering shops there is little work beyond repairs. Public works have been stopped, the Government departments having exhausted their credits, and for the work which must be done payment is made a year or more after completion.

Bad as these conditions are, they are intensified by the labour troubles. Working hours have been shortened and wages increased. The legal working day fixed by the Government at ten and a-half hours has been reduced in Odessa to eight and three quarter hours, and still the workmen are dissatisfied, and seize every opportunity to threaten strikes. The manufacturers fear to take new contracts, even with a strike clause. They do not want their works closed, and they know that every new contract will bring new demands from the workpeople. They dare not dismiss a workman, as they know a strike would follow.

One of the most disquieting features of this situation is that young men and boys are the most disaffected. In more than one instance the boys in a factory have organised strikes among themselves without even consulting the men. Socialist agitators find it easy to impress these younger workers, who are not only more ready to receive new ideas, but also having no one dependent upon them are always ready to stop work.

The employers are in a difficult situation. It is not easy to stand out against the workers, who do not hesitate to enforce their demands by murder and violence. The masters find it almost impossible to combine. There are very few large employers, and the many small ones seem quite unable to keep faith with one another. Otherwise lock-outs might bring the men to their senses. The Imperial Russian Cotton and Jute Factory, a British corporation, locked out its workpeople, numbering nearly a thousand, several months ago. The works were closed for a couple of months, and when they were re-opened the workpeople gladly returned, and there have been no labour troubles in this factory since.

Building operations in Odessa are also at a standstill. In this whole city of half a million people not half a dozen buildings are in course of erection. Landowners do not care to build, and capitalists are slow in advancing money for such purposes. In the past most of the capital used for building has been furnished by the Odessa City Credit Company, a bank which performs the functions of a building society. Advances are made, not in cash, but in bonds of the bank, which are bought and sold on the Odessa Bourse. In 1899 the bank made advances aggregating twenty million roubles, or more than two millions sterling. This year the advances will not amount to a million and a half roubles.

In 1899 the bonds, which bear interest at 4½ per cent., stood nearly at par. To-day they are at 68. Naturally, nobody cares to borrow money under such conditions, when they cannot tell how much they may be called upon to repay. The bank accepts repayment in its own bonds, but it is impossible to tell what these may be worth when the mortgagor desires to redeem his property.

OBITUARY.

WILLIAM JACOB PRIM.

THE death occurred last week of William Jacob Prim, who for many years held the post of resident engineer at the Houses of Parliament, Westminster. Mr. Prim in his early days was associated with the Manchester Steam Users' Association, of which Mr. Lavington Fletcher was then the head, and was still young when he was appointed to the Houses of Parliament. The difficulties with which he had to contend, though great when he took up his duties some forty years ago, increased with the growth of sanitary and hygienic science. Members of Parliament became more difficult to please as their numbers became augmented, and the complaints concerning the quality of the atmosphere and temperatures which the resident engineer had to contend with were frequently sufficient to distract most men. As showing the difference of sensations which had to be coped with, Mr. Prim had more than once complaints of a diametrically opposite nature from two members sitting together. Yet it was his duty to please everybody. The difficulties to be encountered in providing a pure and equable atmosphere in both the Houses of Commons and Lords are increased by the intricate plan on which the buildings were erected. One of the largest works which were carried out in Mr. Prim's time was the reorganisation of the sanitary arrangements. The main sewers formerly discharged their contents into the Thames at low water, but with the new construction of the metropolitan sewers the Shone hydro-pneumatic system became necessary to raise the sewage to a higher level. Other improvements were made in the ventilation, lighting and warming. Mr. Prim may be said to have succeeded in a difficult task, and his courteous manner and kindly consideration of those beneath him made him highly respected. An Irishman, with a fund of native humour, Mr. Prim was on friendly terms with many great public men He died, after several years of retirement, at the ripe age of seventy-six, at his home in Wimbledon, and leaves a son and three daughters.

ELEVEN MONTHS' CLYDE SHIPBUILDING.

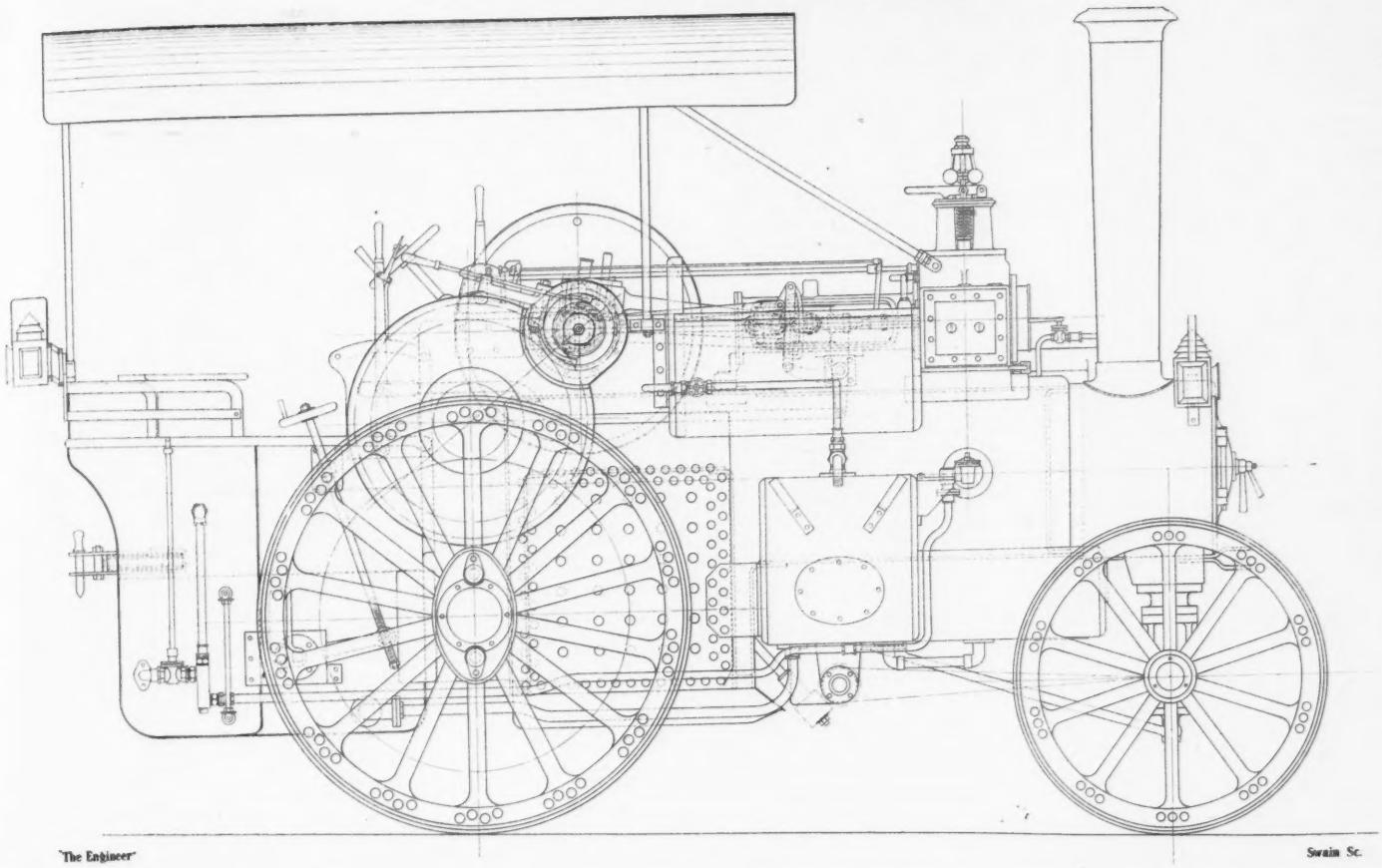
CLYDE shipbuilders have launched, and mostly completed, during the eleven months of the year now passed some 318 vessels, having an aggregate tonnage of 532,600 tons. This compares with 282 vessels of 550,800 tons for the corresponding period of last year. The fact that three dozen more vessels have been launched during the eleven months period this year than last year, while the tonnage is less by some 18,620 tons, is accounted for by the production last year of such huge vessels as the Lusitania, the Agamemnon, &c. The tonnage output for last month was 32,800 tons, or some 5000 tons less than the previous lowest monthly contribution. The probable output during December, while it will no doubt form an average figure, will not be such as to compensate for the lower output during the last two or three months It is, therefore, highly improbable that the promise of the first half of the year that 1907 would exceed all annual records will be fulfilled. Work on hand is being rapidly got through, and many of the largest yards have little to show on the stocks, some of them being indeed without a keel. Even in the Greenock and Port Glasgow districts, where, as a rule, berths are occupied when there is great bareness in other districts, depression has already made itself felt. The ranks of the unemployed are constantly being swelled, as contracts are concluded. One of the yards in Port Glasgow has been practically inoperative for six or seven months, and not only workmen, but heads of departments have been discharged. In Greenock the east yard of Scott's Shipbuilding and Engineering Company is being closed, the only remaining vessel having been launched a fortnight ago. The fresh contracts being booked are very meagre, and of little importance considered as work involving activity in all branches of the shipbuilding industry. The fresh tonnage placed during November has not amounted to more than 12,000 tons.

H.M. DESTROYER GHURKA.

THE Ghurka, which is of the same general type as the Tartar and Mohawk, of which mention is made in our monthly notes, completed her official trials last Friday. She was built by R. and W. Hawthorn, Leslie and Co., Ltd., and her dimensions are 255ft. long and 25ft. 6in. beam. Her displacement is 864 tons. She is fitted with turbines of the Parsons type, which have been constructed by her builders, and has three propeller shafts. Oil fuel is used. Her speed over the whole of her six hours' full-power trial worked out to 33·91 knots, while the mean of six runs over the measured mile during the fourth hour of her trial gave a speed of 34 knots. Her highest speed on the measured mile was 34¼ knots. It is noteworthy to record that having completed her trial off Yarmouth last Friday evening, she ran for Sheerness, and after having taken in some oil fuel, set out for the Tyne at 8 a.m. on Saturday last. She arrived off the piers at the mouth of the river at 6 p.m. on the same day, having thus covered the distance in 10 hours, or at the mean rate of 27 knots. This speed was, we understand, easily maintained when using only four-fifths of her boilers. The boilers, we may add, are of the latest Yarrow type.

COMPOUND STEAM MOTOR TRACTOR

CLAYTON AND SHUTTLEWORTH, LIMITED, LINCOLN, ENGINEERS



ELECTRICALLY-DRIVEN COLLIERY PUMPS.

Two interesting pumps recently constructed for colliery work by Messrs. Frank Pearn and Co., Limited, Manchester, are illustrated on page 572. Fig. 2 represents one of two sets of horizontal three-throw ram pumps supplied to the Wallsend and Hebburn Coal Company, Limited, for Hebburn Colliery, near Newcastle-on-Tyne, under the supervision of Mr. C. W. Fairweather and Mr. R. S. Anderson, agent to the company. The pumps are driven through cotton ropes by three-phase 40 cycles, 600 volts motors supplied by the British Westinghouse Company, and when running at 375 revolutions per minute consume 210 B.T.U. The combined efficiency of the motor and pump is about 75·6 per cent. Each set of pumps is capable of delivering 630 gallons per minute against a head of 1100ft. The rams are 12¼in. in diameter by 18in. stroke, and work at the very moderate speed of 29 revolutions per minute. The advantage of slow-speed working is obvious. The minimum of attention is required, and no appreciable wear will take place for many years. The first motion shaft carries a rope pulley 13ft. 3in. diameter, with thirteen grooves for 1¼in. ropes, and is carried in adjustable gun-metal bearings. The crank shaft is driven from either side by means of single reduction gearing, the wheels being of cast steel made in halves, with machine-cut teeth. The crank shaft is of forged Siemens-Martin steel of the sweep type, and is annealed after being rough turned. It is carried in four adjustable gun-metal bearings. The connecting-rods are solid forgings, and have adjustable gun-metal bearings at each end. The pump barrels are similar; all flanges, as far as practicable, are fitted with bolts, no studs being used. The valve-boxes for both the suction and delivery branches are all interchangeable. The rams are of solid gun-metal, and bolted to the crossheads. The stuffing-boxes are fitted with loose gun-metal neck rings, and the glands are bushed with the same metal. The crossheads are of cast iron, with ample wearing surfaces, and working in slipper guides. The base plate on which the pumps, crank, and intermediate shafts are mounted is in three separate sections bolted together. The pumps are fitted with a by-pass valve, delivery and suction air vessels, and Wipperman and Lewis air chargers.

The set of pumps shown in Fig. 1 have been supplied by the same makers to the Rand Collieries, Limited, Johannesburg. They are also of the three throw ram type, but run at a higher speed than the pump previously described, and are driven by single reduction spur gearing direct by a British Thomson-Houston three-phase motor of 75 brake horse-power, running at 480 revolutions per minute. This set is capable of delivering 10,000 gallons per hour against a head of 1050ft. The rams are 6½in. diameter by 9in. stroke, and the crank shaft makes 60·66 revolutions per minute. The motor shaft carries a steel spur pinion, which gears with the cast iron spur wheel, made in halves. The teeth of the latter are accurately cut. The crank shaft is a Siemens-Martin steel forging, and is of the combined sweep and overhung pattern; it is carried in three adjustable bearings. The construction of the connecting-rods and pump barrels resembles those already described. The valve boxes are three in number, a suction and delivery chamber being embodied in single castings provided with separate doors for the valves. The rams are of cast iron, working through gun-metal neck rings and cast iron glands. The crossheads are cast on the rams, and are fitted with steel pins firmly secured, and work in slipper guides. The whole of the pumps, crank, and motor is mounted on a common bed-plate, which contains three castings bolted together. An alleviator by-pass valve and suction air vessel complete the installation.

COMPOUND STEAM TRACTOR.

THE steam tractor or light-weight traction engine is one of the most powerful competitors of the motor van or lorry, and the old firms who have been accumulating experience with all kinds of haulage engines for many years past, are turning their knowledge to good account by continual advances in handiness and economy, and are thus keeping well abreast, if not ahead, of their new rivals.

As an example of the latest developments in this direction, we illustrate a little engine which Clayton and Shuttleworth, Limited, will exhibit at the Smithfield Club Show next week. It is called the "Little Hercules" steam motor tractor, but in spite of its name it is nothing more nor less than a small compound steam traction engine. It has cylinders 5in. and 8in. in diameter, with a stroke of 8in., and steam is distributed by ordinary cast iron flat slide valves. The pistons are of malleable iron, and are fitted with Ramsbottom rings. Trunk guides bored out are used. The side plates of the fire-box shell are carried upwards and backwards to support the bearings for the shafts and main axle, the crank shaft and axle bearings being let into recesses in the side plates. The fly-wheel is 2ft. 9in. diameter, is of cast iron, is turned to take a driving belt, and is provided with a hand brake. The whole of the gearing, including the compensating motion wheels, is of crucible cast steel. The first and second motion wheels are machine cut, and the double first motion pinion slides on a square shaft, so dispensing with keys. The driving wheels are 4ft. 10in. diameter, and 10in. across the face. They are constructed of steel tee rings and steel spokes cast into the hubs.

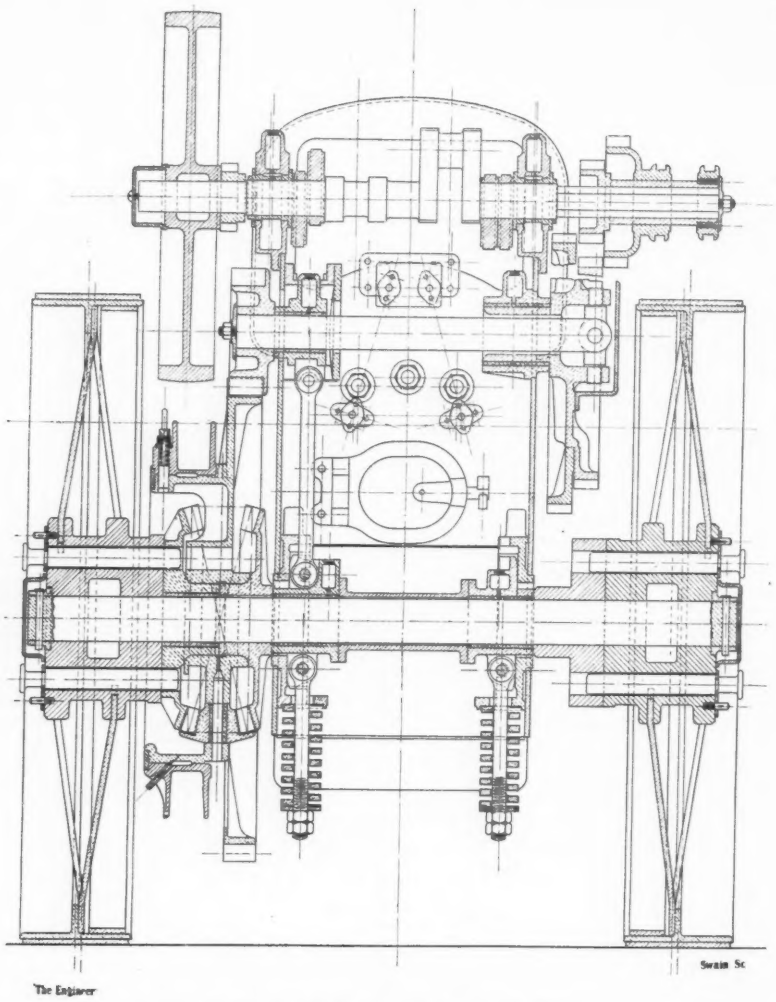
STEAM MOTOR TRACTOR

The boiler is tested to 280 lb., and intended for a working pressure of 180 lb. It has forty-one steel tubes 11 B.W.G., swelled at the smoke-box end and expanded into the tube plates. The fire-box crown is stayed direct to the arch of the outer shell, no roof bars being used. The boiler is very carefully made, all the rivet holes being drilled in position after the plates have been bent. Punching rivet

holes has been quite given up in the best boiler work.

The tractor is mounted on springs, and the footplate is fitted with spring-board flooring still further to minimise vibration, to the advantage of the driver. Steering is effected by worm gearing and a hand wheel, and the steerage chains are attached to springs, which relieve them from shocks when travelling over rough roads. Strong brakes are fitted to the hind wheels, which enable the speed of the engine to be effectively controlled when descending steep gradients. A slip winding drum, with a supply of flexible steel wire rope running through suitable guide rollers, is provided. The tender is large enough to carry a good supply of fuel and water, whilst two extra tanks are fitted beneath the boiler barrel to provide for long runs without stoppages to take up water. The feed pump is of the continuous action type, having gun-metal valve-boxes, clack valves and bonnets, and is driven by gearing from the crank shaft, thus reducing the speed of the ram, and decreasing the wear. It is bolted to the hornplate, and placed within easy reach of the driver. A strong but light awning is fitted over the tender, and the usual traction engine equipment is provided. The "Little Hercules" is designed to travel at from five to eight miles per hour, with a load of from five to seven tons, on ordinary roads.

We give a general view of the engine, from a photograph, a side elevation and a cross-section through the gearing.



STEAM TRACTOR—CROSS SECTION THROUGH GEARING

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE PREVENTION OF RAILWAY ACCIDENTS.

Sir,—As a former railway officer, I have taken no little interest in railway accidents and their causes and prevention, so the comments contained in your editorial of the 22nd instant attracted my attention; but, naturally I found still more interest in what you said as to railway signalling.

Reference is made to earlier days, when speeds were, comparatively speaking, low, and the lines were not crowded, and it is asserted that if the machinery, workmanship, and material had been as good thirty years ago as they are to-day accidents would scarcely have occurred at all.

The period of thirty years ago was, I assume, chosen at random; but, as I will attempt to show, it is a very interesting period. In order to make comparisons with the present day we must take the figures for 1906—those for 1907 not, of course, being available—and compare them with 1876, and it may be instructive to include those for 1886 and 1896. This is what the annual reports for those years tell us:—

	1876.	1886.	1896.	1906.
Train mileage, millions	215	277	373	414
Number of passengers, millions	538	725	980	1240
Collisions and derailments	470	220	214	289
Passengers killed in train accidents	38	8	5	58
Passengers injured in train accidents	1279	615	888	631
Servants killed in train accidents	28	4	3	13
Servants injured in train accidents	236	81	153	14

Before commenting on these it may be interesting if I add the following as confirming what you said as to improved machinery, &c.:—

Failures of tires	880	866	433	137
Failures of wheels	74	1	3	1
Failures of axles	397	329	183	148
Failures of couplings	30	8	10	21
Broken rails	464	247	302	264

Returning to the first set of figures above, it may be remarked that it is a strange coincidence that the period of thirty years ago was chosen, as in the matter of passengers injured in train accidents, servants killed and injured in train accidents, and the number of collisions and derailments, the figures for 1876 have not since been equalled. Another coincidence is that the figures for last year—1906—were very unfortunate. This is an admission in favour of your argument, I grant; but the point I want to make will be best put if I say that there would have been a better showing had it been 1905 instead of 1906. Singularly enough, the number of passengers killed—thirty-nine—in train accidents was the highest since 1874, except the Tay Bridge and Armagh disaster years, but the number of passengers injured in train accidents, compared to the number carried, has only once—in 1897—been bettered, whilst the number of servants killed and injured in train accidents is much below the average.

The fact that 1905 was not a bad year is, of course, no argument when one has to admit that the results for 1906 are unsatisfactory. Let us, however, see whether some grain of comfort may not be found. The criterion I always advance as to the management of railways is the number of collisions and derailments taken in proportion to the train mileage. As has been seen, there were 470 such mishaps in 1876, and this figure decreased year by year thus:—345, 306, 272, 265, 298—in 1881—to 220 in 1886. Except in 1891, when there were 235, it did not rise again until 1899, when there were three bad years running of 291—in 1899—299, and 276. The five remaining years—1902-6—have been 223, 235, 217, 199, and 239 respectively. Yet all the while the mileage has been growing, and in 1906 reached the record of over 414 million miles, which means an average of one mishap to every 1,733,202 miles run—an average that has only been bettered eight times. (That for 1905 has only been bettered four times.)

I must now admit that I have advanced all my arguments, but I trust that I have shown that British railways in the matter of safety are not deteriorating as rapidly as you suggest—or I imagine you suggest.* We have had some nasty knocks during the last year or two, owing to enginemen and signalmen failing in their duty, but it is a rare thing now for the Board of Trade to condemn a system of working, as they did twenty and thirty years ago. As you observe, "Accidents are the result of the breakdown of the man and not of the machine," and it seems to me that in these days of the block system, interlocking, continuous brakes, &c., it is no longer, as thirty years ago, when these things practically did not exist, a question of "the greater the danger the greater the safety." Trains are much heavier, and run at a higher average speed, and consequently when there is a mishap it ends in disaster.

Your editorial refers to automatic signals and automatic train control as being desirable. These are subjects I will deal with directly. In the meantime, I will refer to what has been done to control the action of signalmen, whereby they are prevented from indicating on their block instruments that a train has arrived unless it has actually arrived, and from lowering their outdoor signals for a train to proceed towards the next signal-box unless such a train has been "accepted" on the block instrument by the man at the advance box. This is known as "lock-and-block."

The principal system of "lock-and-block" is the Sykes, which is used throughout the South-Eastern and Chatham, and very extensively on the London and South-Western, Great Eastern, Caledonian, North British, Glasgow and South-Western, and some smaller lines. The Spagnoletti is used on the Metropolitan, the Langdon through some long tunnels, on the Midland, and, there are a few other systems. There is interlocking between the block instruments and the signal levers that prevent the latter being used until the block signals have been exchanged, and that compels the signal levers to be restored so that they cannot be left "off." The train itself controls the block instrument by means of a contact maker on the line, which, being depressed, causes an electrical current to take a lock out of the block instrument and permits the signalman to give the train-arrived block signal.

This form of control over the signalmen's movements has not made much progress of recent years, but that is not due to any defect in the system, but because it does not go far enough. For instance, it does not guard against a divided train, where there is a possibility of the signalman not noticing that the whole of the train had not arrived and when the first portion passed over the contact and released the lock, giving the "train-out-of-section" signal.

Personally, I prefer the track circuit system as used so extensively in America, and which is getting gradually introduced here. When first tried here—ten years or so ago—it was a failure. This was due to various reasons which need not now be referred to, as the fact that it is used on the Great Western, Midland, North-Eastern London and South-Western, Lancashire and Yorkshire, Great Northern, Great Central, Metropolitan District, and the London Tube railways testifies to the satisfaction it now gives. I think that its use on the main line of the Great Western near Goring is eloquent testimony, as that company's system of signalling is, in my opinion, the finest in this country, and they are so cautious and careful.

By the track circuit system the rails in a block section are bonded together by a light iron or copper wire, and at the outgoing end of the section is a battery joined up to a relay at the ingoing end. The presence of a train or part of a train in the section short-circuits the current, so that the relay is inoperative, and, consequently, the signal for entering the section cannot be lowered. A broken rail will also short-circuit. This is an effective "lock-and-block," and meets the divided train difficulty. In glancing through the Board of Trade reports on accidents for 1906 I find it would have avoided at least seven collisions:—Crowthorn Junction, St. Mary's Junction, Derby; Edge Hill (two), Preston, Tapton Junction, and Thurstonland tunnel.

It is track circuits that make automatic signals possible. This is a subject you refer to, and I want to say that the reason that automatic signals have not made greater progress in this country is not due to any defect or deficiency in the system nor to any want of confidence. Here, again, the Great Western furnish a proof, as the track circuit system at Goring, already referred to, is used partly in connection with automatic signals. It has solved the difficulties of the Great Central as to the long block section on the up line through Woodhead tunnel, and at a point south of Leicester, and other such sections are proposed. The London and South-Western were the first to equip a steam-worked line, which was over five years ago, and they have now many automatic signals, whilst the Metropolitan District and the London Tube railways could not work their frequent service were it not for automatic signals.

The reason they have not made greater progress does not mean, as I have said, any want of confidence, but that our lines are already equipped with signal-boxes and mechanically-operated signals, and, of course, whilst the men may and do make mistakes, they retain the human agency.

Coming now, lastly, to the question of the automatic control of trains. This is not a new subject; far from it. It is generally associated with signalling during foggy weather, and I doubt whether there is any part of signalling that has furnished more matter for letters patent than that for signalling to a driver as to the state of the fixed signals. As you dealt with this subject fully as recently as October 18th, in your editorial on the Shrewsbury accident, I am not going to say more than refer your readers to the opinions therein expressed, with which I agree. I would, therefore, close by asking to be allowed to quote the following from Colonel Yorke's report on the Slough accident:—

"In consequence of this collision, considerable prominence has been given in the public Press to the suggestion that some mechanical contrivance working in conjunction with the semaphore signals should be adopted, to render it impossible for a driver to pass a danger signal without becoming aware of the fact. Many such appliances of varying degrees of merit have been invented, several of which have been brought under my personal observation, and a few of which are under trial. Some of these cause a bell to be rung on the engine, or the whistle to be sounded, as soon as the engine has gone past a signal which is at danger. Others cause the continuous brake to be applied automatically without any action on the part of the driver, while a few, in addition to operating the brake, go so far as to aim at shutting off steam. Some are wholly mechanical; some depend on electricity or magnetism; some are partly mechanical and partly electrical. They all consist of two parts; one, an apparatus placed alongside of, or between, the rails, and connected by rod or wire with the signal in conjunction with which it works; the other, an attachment on the engine, the operation of which depends upon the position of the apparatus on the ground, which in turn depends upon the position of the signal. The object aimed at by such a device is to substitute the (assumed) reliability of a machine for the uncertainty of the human agent—or driver. It is impossible to adequately discuss the subject within the limits of this report, but one or two remarks may be made with a view to removing certain misconceptions. The efficiency of such an appliance would depend upon the care and intelligence bestowed upon the maintenance of its separate parts. Human agency is therefore not eliminated; the reliance, withdrawn from the driver, is merely transferred to the man or men whose duty it is to look after the new apparatus. But even with the most careful maintenance, some portion of the mechanism might suddenly fail or be thrown out of gear, in which event the most dangerous condition of affairs would arise. For drivers, having been taught to rely upon the apparatus, would pay less heed to signals than at present; in fact, one newspaper in describing some recent experiments with one of these inventions, speak of it as 'minimising very greatly the importance of semaphore signalling,' a consummation by no means to be desired. Unless, therefore, it can be rendered absolutely proof against failure under all conditions of speed, weather, or accident, the use of such a machine may in roduce greater risks than those which it was intended to remove. It is also to be borne in mind that if used at all on any railway, it must be used in connection with every 'stop' signal, and although the fixing of some such apparatus alongside a railway track for the purposes of experiment or demonstration is a simple operation, I anticipate that considerable difficulty would arise, when laying down a large number of these appliances at large stations or junctions, especially where signals are 'slotted' or controlled from two signal boxes, or where several routes, each with its separate signal, diverge from one trunk line. These observations will suffice to show that the conditions to be met are by no means so simple as may at first sight appear, while the inventions claiming to attain the object in view, which are now before the railway companies, have not yet emerged from the experimental stage."

I regret taking up so much of your valuable space, but the subject is one on which, I believe, I am regarded as somewhat of an authority.

H. Raynar Wilson.

November 27th.

PREMIUM AND NO PREMIUM.

Sir,—I hope we may take it that whether a premium is paid or not, the object of the practical training of young men in workshops is to make efficient engineers of them. The point, then, we ought to be discussing is whether the premium or the no-premium system does this best. I propose to show some of the difficulties the premium apprentice works under, and so account for his inefficiency.

The incompetence is due partly to his parents and guardians, but in a much greater proportion to the engineers under whom

* We have suggested nothing of the kind. Our argument is that a higher degree of safety than has now been obtained is not possible with the present arrangements. Our meaning being, of course, that the standard is so high that there is little room for improvement.—Ed. The E.

he has been trained. The present low market value of engineers is partly due to both the incompetence and the surplus supply of engineers.

It will be rather interesting to analyse these causes, and see if there is no way in which these evil effects cannot be modified, or even entirely eradicated.

To deal first with the parent, or whoever may be responsible for the lad's education and training. Presuming the engineering profession has been chosen for a particular youth, his father proceeds to find an opening at some works for the lad, and has an interview with the manager or whoever the head of the concern may be, to arrange terms, such as premium, and length of apprenticeship, &c. When this has been satisfactorily settled he goes home, and in the majority of cases considers he has done all that is required of him, beyond supplying the necessary cash to keep the lad, to make him an engineer, or possibly when the youth goes home for his periodical holidays he will be asked a few desultory questions, such as "Well, how are you getting on at the works? Are you working hard and learning all you can? What department are you in now?" To all of which he will naturally give satisfactory answers, as not to do so would, in the majority of boys' opinion, convict him of laziness and inattention to their work, with a consequent stoppage of pocket money, or some other objectional evidence of their parents' displeasure, and in any case a lad is not in a position the first couple of years to know whether he is making the progress he ought to be or not.

The question naturally arises, What more can the father do, and how is he to blame? as generally he is not an engineer, so cannot go into details with the lad. The question is most easily answered by giving a parallel case. Suppose a man has a sum of money to invest, and has no inside knowledge of the money market, what would he do? If he wished to make a sound investment, he would consult his solicitor or broker, and obtain expert advice on the matter, and after the money was invested he would instruct his solicitor to watch his interest, and see that the investment remained good, or advise him to change it. That is precisely what he should do in the case of his lad, if he is not an engineer himself. He shou'd obtain some outside expert's opinion of the suitability of the firm he proposes articling the lad to, and periodically send the lad to this expert, who will put him through a catechism on his work, and go thoroughly into it, to see that the lad is making the progress that he ought, and being taught his profession in such a manner that he will have some moral right to style himself a mechanical, electrical or hydraulic engineer, as the case may be, when he has finished his apprenticeship. Also by following this procedure the parent would be advised as to the mental and physical fitness of his son, for what is, if any responsible position is aimed at, one of the most arduous and exacting of the professions.

To turn to the second and more directly attributable cause—the firms and individuals who are responsible for the training of these incompetent men. The firm receives a sum of money as a premium, and for this undertakes to train the lad in the profession of an engineer! Do they fulfil their obligations? In some cases yes, and thoroughly too, but unfortunately in a great many instances they do not, or, at the most, only do so in a very perfunctory manner, and these are the firms who are directly responsible for the majority of the half-trained engineers in the profession. Some young fellows there are, of course whom no amount of care and attention could ever make into ornaments, or even useful members of the engineering or any other profession.

Now, perhaps, a few instances of this neglect, to call it by its mildest name, on the part of the employers, will serve to show the truth of these statements. A youth of, say, sixteen, is articled to an engineering firm for a period of five years. He is probably sent into the machine shop to commence his training; there he is set to work some simple machine, such as a small drill or slotting machine. So far well and good, but is the class of work given him to perform improved on as he gets older and more accustomed to his machine? No, except in a very small degree it is not, and for two reasons. First, because the machines allotted to beginners are of a necessity the machines used for the roughest and least expensive class of work, as, of course, it would not be an economical policy to permit a raw hand to perform any operation on a casting or forging that had already had many pounds worth of work put into it. Secondly, because the lads themselves do not progress as rapidly as they ought in acquiring skill in operating their machines, and this lack of progression on their part is due to the insufficient attention and interest devoted to them by the shop foreman under whom they work. This state of affairs is not to be wondered at when the foreman's position is examined. He is a very busy man with but one aim, and that is to get the greatest possible amount of work through his department in the shortest possible time; he has no pecuniary interest in the apprentices under him being taught their work properly, and, in addition, has little or no time to spare to teach them, as it pays him much better to devote his time to the skilled machinists, who understand their work, and can get more work out of their machines than any apprentice. So the lad goes from one department to another until he has been right through the works, picking up a little knowledge here and there, but generally left pretty much to his own devices, which, being a lad, and more or less mischievous, naturally consist of getting as much fun out of it as possible, dodging the "boss," and, in fact, doing anything but learning his profession. Occasionally a youth shows a determination to learn all he can, and by dint of worrying everybody he comes under to give him information and allow him to perform a constantly improving class of work, he thoroughly learns his profession; but these lads are few.

Happily, these conditions are not universal in the engineering works of this country. There are many works where the heads of the firm have given this question of training apprentices considerable thought and attention, and who does his utmost to train them properly by care and attention to the lads while they are in the shops, and by offering various inducements in different forms to encourage the lads to attend the science classes in their own and their employers' time, but, unfortunately, there are a far greater number of firms who do not give the matter any attention at all beyond the financial one of premiums.

Or, again, take a case of a youth articled to an electrical engineer at some power station. The usual period is for three years, and at least the first twelve months of this is generally spent on the switchboard as understudy to the switchboard attendant, and occasionally during the latter part of the time taking charge of the board on emergency occasions during light shifts. The remainder of his time will be spent partly with the station fitters and wiremen and partly with the mains engineer, knocking about the mains. At first sight this looks to be a fairly suitable programme for the training of a power station electrical engineer; but let us examine it a little more minutely. To begin with, one year out of three, or one-third of the whole apprenticeship, is spent on the switchboard; in many cases even more time is spent here. Is this time necessary for the learning of this section of the work? If a lad has even a moderate amount of smartness he will learn all that is essential to him of switchboard work in six months, and even less if he has some previous knowledge of the theory of electrical circuits. The first three months he will take an interest in his work, and worry the attendant in charge of the board to explain its operation and the different connections on it; then when he has mastered this, or thinks he has, the monotony of the work will begin to exert its influence, and he will get into slack ways, in nine cases out of ten, through not having enough work to do to satisfy his, at this age, somewhat active nature. From the switchboard he is, perhaps, sent to the wiring and motors department. There, to begin with he is of little use, except to fetch and carry, through his not having any experience in the use of tools, but later on he will get a little experience in temporary and small extension wiring, as few of the power stations in this country have a full installation wiring department. His time with the fitter will also be fairly profitably employed, as the fitting staff being generally small the fitter will be glad to teach him, so that he may be of some real use to him as early as possible. Unfortunately, the time spent on the mains with the mains engineer and in the office is often not utilised to the greatest advantage. He sees a little of how cables are laid and joints made, &c., but his time is principally spent running errands backwards and forwards to and from the station, and in the office entering up records and such-like work.

What is the result of this? When his articles are completed he looks about him for a position as a junior assistant engineer at some works, and after unsuccessfully applying for several, he comes to the conclusion that all he is fit for is a position as switchboard attendant at a salary of, say, a pound a week.

The faults of this system of training are:—Too much time spent on the switchboard to begin with; half of it would be much more profitably spent in a suit of overalls with the wiremen, fitters, or in the stokehold. The time spent with the mains engineer would be more profitable if the same suit of overalls were donned and the lad were sent down into the trenches and boxes with the jointers and cable gang, and got his knowledge of cable work by assisting at it—not looking on while others did it—and the office time devoted to making drawings and tracings, than on logging records.

To look at the question from a moral point of view—Is it fair that any individual should accept a premium, often running to hundreds of pounds, under conditions such as have been enumerated above, if he cannot conscientiously persuade himself that he earns it?

If a man chooses to accept a premium for teaching a youth his profession or trade it should be his personal duty to see that the youth is taught, and thoroughly taught that profession, either by himself or others whom he may depute to do so; but undoubtedly this is the opposite of what is done in too many instances. There are firms and individual employers who do take a real and live interest in their apprentices, and fortunate indeed are those who are trained under these employers; but, undoubtedly, there are a very much larger number of employers who are content to draw the premiums, and pass the lads through their works and offices, absolutely indifferent as to whether they are or are not being thoroughly taught and initiated into the details and intricacies of their work.

Were our apprentices better trained, better educated, and harder worked during their apprenticeships, we should see fewer German, Italian and American engineers taking some of the best and most lucrative positions, at the disposal of the English employers, as at present they are doing in a great many instances, and there is no doubt that they are here, because our own supply of really well trained, capable, and industrious young engineers in this country is not equal to the demand, although the supply of men seeking good positions is far in excess of the number required.

How many of our young engineers of 24 to 30 years of age who have served their apprenticeship, and are, therefore, supposed to have been taught their profession, if put through a plain straightforward catechism by a thoroughly practical man, would come out with flying colours—aye, or older men either?

SWITCHBOARD.

MINING IN CUMBERLAND.

SIR,—I have again read with considerable interest your annual report on the mineral statistics of the United Kingdom, and consider that, whilst we have some particulars of British metal mining before us, it will not be inappropriate to make some reference to that particular part of Cumberland and Westmorland known as the Lake District.

In a statistical article, dealing solely with output, very little of moment could be said about the above district; nevertheless it may be of interest to some readers to learn that a greater activity has recently arisen in metal mining in the Lake District than has existed for several years.

Taking the district in detail, it will be found that the Greenside lead mine, near Helvellyn, and the Thornthwaite lead and zinc mines, near Bos enthwaite, are still good producers, and the same remark also applies to the Threlkeld lead and zinc mine at the base of Saddleback. This last mine was reopened about two years since, and another mine in the same locality is, I understand, going to be reopened shortly.

The Force Crag mine, near the mountain Grisedale, has been re-opened by a newly-formed company, and there is every likelihood that this mine may soon become a good producer in lead and zinc, the former being fairly high in silver.

A company has recently been prospecting along the Vale of Newlands, and is, I believe, going to work the copper veins which exist near Dale head, and which were superficially mined at an early date.

The Yewthwaite and Barrow lead mines are also under similar consideration.

The majority of the above mines are in the Skiddaw slate, and have yielded large quantities of mineral in the past compared with the relatively small amount of development to which they have been subjected.

Attention is also being called to the once famous mining field lying to the north of the Lake District, and known as the Caldbeck Fells. A considerable quantity of the tungsten-producing minerals, namely, wolfram and schulite, have recently been mined in the Skiddaw granite at Brandygill.

Practically the whole of the Caldbeck Fells, consisting of some twenty square miles of valuable mining property, was recently acquired by the Caldbeck Fells Mining Syndicate, and is now held by the Cumbrian Mining Company. One of the mines, named Daiggeth, has been re-opened and a concentrating plant erected.

Prospecting is being conducted on the large barytes vein which is supposed to run through the mountain Buisey, and a company has been formed to work the mineral on a large scale.

The principal drawback to the Caldbeck Fells as a mining field for low price ores is the lack of railway transport. A railway has been projected more than once, without result; indeed, the only prospect seems to lie in the by no means improbable chance of a discovery of hematite near the base of the Fells, which by its promise of large tonnage might induce one of the local railways to make an extension.

Thanking you for the valuable space you have so kindly given to this letter.

JNO. W. BRANSTON.

Carlisle.

FRICTION AND LUBRICATION.

SIR,—In reference to your current leader on this subject, I regret that you have quite failed to grasp the significance of the method of designing bearings now proposed. The mathematical work of Osborne Reynolds and Sommerfeld, and the experiments of Thurston, Stribeck, Dettmar, and Heimann, have demonstrated the existence of a minimum value for the frictional resistance of a journal in its bearings as the speed falls to nothing; the values of the rubbing speed at which the minimum takes place depending on three things: the bearing pressure, the temperature, and the kind of oil. The physical causes of this phenomenon make it clear that bearings which are to be run with "complete lubrication"—Osborne Reynolds' term—can only be rationally designed by a study of the conditions under which these minimums occur.

The knowledge of these conditions is to be used, however, for the purpose of avoiding them; emphatically not, as you have supposed, to reduce the "power wasted in friction to a minimum." The minimum points are pitfalls, which must be cleared with precision and by a proper factor of safety. They therefore govern the designing of bearings.

Assume a bearing which, under a steady load at constant speed, has attained its final temperature, and which happens to be then just running at the minimum (or, as I prefer to call it) the "critical point." Its oil film will then be as thin as it can be without rupture under the given conditions. A slight lowering of speed, an increase of load or a rise of temperature will break it, and allow metal to metal contact with great additional friction. To ensure continuance of good running we must either diminish the bearing pressure or the temperature, or increase the speed.

It is generally believed that lengthening a journal will make it run cooler even if originally running with a complete film separating it from its bearing. There is neither experimental evidence nor theoretical ground for this belief. The diminution of pressure in the oil film (caused by the lengthening) has no effect on the frictional resistance per square inch of bearing, and the friction-work turned into heat therefore increases proportionally with the length; but the heat-emitting surface also increases proportionally with the length; therefore the temperature will not change.

If, then, we lengthen the above hypothetical journal in order to improve its running, it is done not to lower the temperature, but because, by diminishing the bearing pressure we have a larger margin for avoidance of the critical point. It is to be further observed that the higher the speed the shorter the journal may be. This is in direct contradiction to ordinary practice, which has been quite led astray on this point.

As you are paying me the compliment of publishing my paper *in extenso*, and I do not wish to burden your columns by repetition, I would ask you to defer further publication thereof for one week, during which certain additional diagrams and verbal explanatory matter added at the last meeting will be printed for the next. The *rationale* of the method will then be placed before your readers in a descriptive as well as an algebraic form.

With further reference to your leader, where you criticise the scope of the formulæ, and believe their utility to be far less extended than I suppose, I beg to state that since the "critical condition" is liable to occur in every kind of journal, the new principle of design must apply to all. I have not, so far, had the opportunity of finding the constants for any bearings but those which run at constant speed and under a load constant in magnitude and direction. I have therefore nothing to say in this paper about the bearings of steam engines, but I believe that the application of the critical point method, together with an analytical result of Osborne Reynolds', "Papers," vol. II., page 264, equation (29), will rationalise their design also.

As regards railway axles, the method of the paper applies absolutely. The constants given for line shafting depend on the coefficient of emissivity from Stribeck's bearing running in still air. When redetermined for a railway axle which runs in a gale of wind, they have given exactly the proportions of practice. In other words, railway engineers unconsciously design their journals to avoid the critical point by a small margin.

Finally, there are no bearings running well in practice under "pressures of tons per square inch" except when the sense of loading is continually reversed. This case, as already mentioned, I have not yet discussed; but the same principles of design apply, and some of your more interested readers might usefully attempt the task.

JOHN T. NICOLSON.

December 2nd.

THE STRENGTH OF RINGS.

SIR,—Will you allow me space to thank Mr. Moyle for his very lucid exposure of my error by his letter in your issue of November 29th?

It had not altogether escaped me that there might be other than the simple forces suggested by myself to your original querist, since my calculations led to results which seemed not exactly to conform to practice. At the same time, practice in such every-day cases as chain slings is not a very exact guide, since such rings are often left to the foreman smith, who makes them "strong enough."

Reading Mr. Wells's letter in conjunction with that of Mr. Moyle, I think I can quite follow the argument, all but one point, viz., the horizontal force $M_1 = \frac{WR}{\pi}$.

I gather that this force—of which W R is the resultant acting parallel to the line of load—is supposed to act as by molecular stress internally to the material of the ring and parallel to the neutral axis.

Now, on what principle does this theory rest, and can your correspondents, who have been kind enough to reply to "A. H. C.," explain the derivation of this formula without the aid of the calculus. My knowledge—and there must be many like me—is not sufficient to allow me completely to follow Mr. Wells—at least, with any feeling of certainty.

There are, of course, theories which can only be expressed effectively by the calculus, which is one reason why some "practical" men abuse mathematicians as "theorists," instead of their own mathematical ignorance.

Such theories are, however, few I think, and if you, Sir, can afford the space, and your correspondents the time, I feel sure that a clear development of the formula $M_1 = \frac{WR}{\pi}$ without the aid of the calculus, would render this discussion helpful to a far wider circle of your readers, and that, too, even if an absolutely complete proof cannot be given.

Angmering, December 3rd. GEO. T. PARDOE.

ROYAL INSTITUTION.—A general monthly meeting of the members of the Royal Institution was held on Monday afternoon, the 2nd inst., Sir James Crichton-Browne, treasurer and vice-president, in the chair. Miss Joyce Burton Buckley, Dr. L. Gottschalk, Mrs. Robert Home, Dr. D. G. Johnstone, Sir Edwin Ray Lankester, K.C.B., Mr. S. F. G. Osborne, and Miss E. A. Stoney, M.A., were elected members. Professor L. J. Troost, Professor A. Haller, and Professor W. Victor were elected honorary members. The special thanks of the members were returned to Lord Sanderson for his donation of five guineas to the fund for the Promotion of Experimental Research at Low Temperatures. The following are the lecture arrangements at the Royal Institution before Easter:—Sir David Gill, a Christmas course of six illustrated lectures on "Astronomy, Old and New," adapted to a juvenile audience. Dr. A. A. Gray, two lectures on the Internal Ear of Different Animals; Professor F. J. Haverfield, two lectures on Roman Britain: (*a*) its Frontiers and Garrison; (*b*) its Interior Civilisation; Professor W. Stirling, six lectures on Membranes, their Structure, Uses, and Products; Dr. E. A. Wallis Budge, three lectures on the Egyptian Sudan, its History, Monuments, and Peoples, Past and Present; Professor W. W. Watts, two lectures on (i.) the Building of Britain, (ii.) Recent Light on Ancient Physiographies; Major Martin Hume, three lectures on the Story of the Spanish Armada; Professor W. Somerville, two lectures on Wood, its Botanical and Technical Aspects; Professor Sir John Rhys, two lectures on Celtic; Mr. R. T. Glazebrook, two lectures on Physics; Mr. R. Lydekker, two lectures on (i.) the Animals of Africa, (ii.) the Animals of South America; Professor Gisbert Kapp, the Electrification of Railways; Mr. Lionel Cust, two lectures on Anthony Van Dyck; Mr. Selwyn Brinton, three lectures on the Art of Florence; and Professor J. J. Thomson, six lectures on Electric Discharges through Gases. The Friday evening meetings will commence on January 17th, when Professor T. E. Thorpe will deliver a discourse on the Centenary of Davy's Discovery of the Metals of the Alkalis. Succeeding discourses will probably be given by Colonel David Bruce, Professor E. Rutherford, Mr. Humphry Ward, Dr. C. W. Saleeby, Sir Oliver Lodge, Professor W. A. Bone, Professor J. Milne, Professor A. E. H. Love, the Hon. R. J. Strutt, Lord Montagu of Beaulieu, Professor J. J. Thomson, and other gentlemen.

A NEW TUBELESS SEMI-FLASH BOILER.

LAST Monday we were invited to inspect a new boiler, which has been constructed to the designs of Mr. G. R. Steward, M.I Mech. E., of 28, Victoria-street, S.W. It is of unconventional design, as will be gathered from the illustrations we give below. The special features consist in the arrangement of the water spaces and the absence of crown plates and tubes.

The boiler consists of a number of hollow concentric cones which form annular water spaces. These cones are connected together by pipes as shown in the diagram, these connections forming the steam and waterways. The spaces

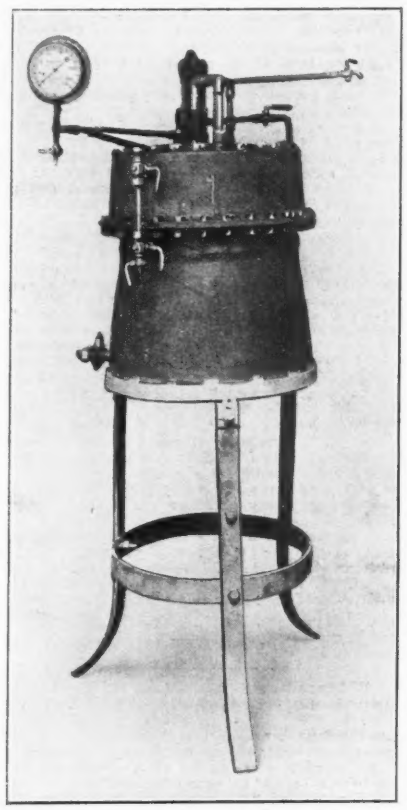


Fig. 1—TUBELESS SEMI-FLASH BOILER

between the cones form the combustion chamber, and thus —with the exception of the outer shell—the water spaces are fired both externally and internally. The main feed to the boiler is carried in at the bottom, and is collected from the special reservoir at the top of the boiler. It will be noticed that the water column in each chamber shows a distinct thinning away towards the water level. We are informed that this has been done with the object of presenting a larger heating surface for the same volume of water at this part where the temperature of the gases is lower. In order to keep the water at a constant level the special reservoir or water belt already referred to was provided. It is fixed to the outer shell or casing,

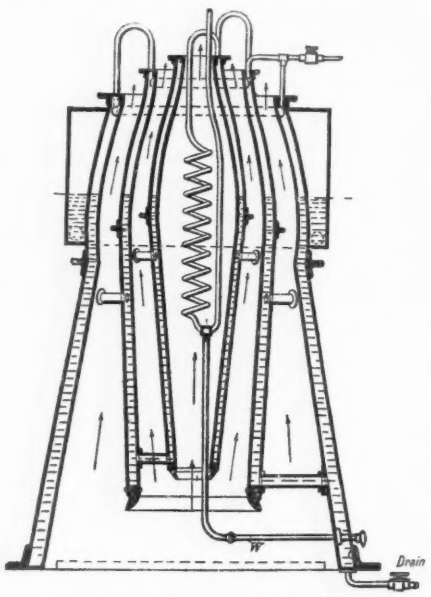


Fig. 2—SECTION OF THE BOILER

and communication is made by small perforations at the bottom of the reservoir for the water to pass into the boiler, and perforations at the top for the steam to pass out. There is a circular pipe—perforated—at the bottom of this reservoir, which is supplied with live steam from the central superheater. By this means the boiler is fed with water which is somewhere near the boiling point.

It will be noticed that the cones have a varying height. We were told that this was done with the double object of giving freedom to the gases at the bottom ends of the several cones, and also of securing an increasing steam space to the central cone previous to the steam entering the superheater. In order to protect the superheater tube from extreme heat while raising steam, it can be filled with water through the tube W up to the water level of the upper cone. It then forms part of the generator, but when sufficient steam is raised it is again closed and performs the function of the superheater. It should be mentioned that the cones also vary in height at the bottom so as to facilitate the draining of the water which passes from the central cone to the next cone, and from that to the outer annular space, where all the water can be discharged through the cock at the bottom.

The extremely narrow water spaces near the top of the boiler would lead one to suppose that there would be priming, but the boiler is claimed to be practically primeless, the reasons given being that the circular pipes at the top of the two outer cones prevent water being carried over, and any that is carried over is converted into steam on reaching the superheater.

We have seen this boiler under steam, and the results obtained appeared to be quite satisfactory. It takes up little space for its power. Its chief dimensions are:—Diameter at the top, 1ft. 6in.; diameter at the bottom, 1ft. 10½in.; height of boiler, 2ft.; and it is estimated to develop 10 horse-power at 150 lb. working pressure. This estimate is calculated on the basis of keeping the working pressure at 150 lb. per square inch, with two ¼in. bore cocks open, and at the same time maintaining the water at a constant level. The boiler was fired with an ordinary oil fuel burner using paraffin oil, and from the time of lighting it took just a little over 6 min. to raise 100 lb. of steam; the pressure then very rapidly rose to 140 lb. The time taken to obtain the first indications of steam was a fraction over 2½ minutes. We were informed that there were four gallons of water in the boiler when the test was started. Steam was then blown off till the pressure gauge recorded zero, and during this time two gallons of water were pumped in. The burner was again lighted, the time taken to raise 140 lb. of steam under these conditions was 3 min. 10 sec. The fire was then extinguished and two cocks opened. Steam was given off for some time, and the pressure did not drop very quickly. We did not take the temperatures above the burner and at the top of the boiler, but we are informed that the former temperature approaches 3000 deg., and the latter between 700 deg. and 800 deg. temperature. We were also told that the superheat was about 500 deg.

The diagram shown in Fig. 2 does not show the actual construction of the boiler and is only intended to be diagrammatic. In later designs one or two modifications are to be embodied, which, we think, will further increase the efficiency of the boiler.

AN INSTRUMENT FOR TESTING HARDNESS.

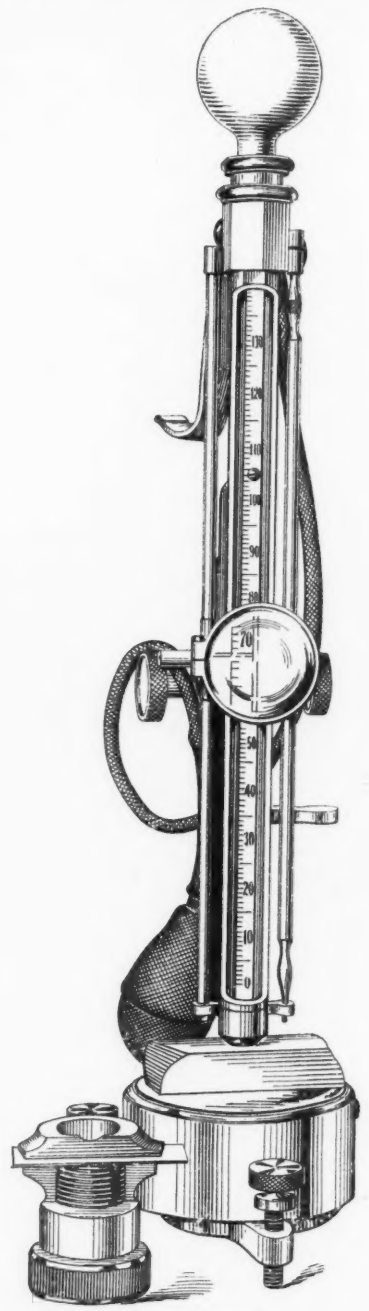
AN interesting article by Alfred F. Shaw appearing in a recent issue of the *American Machinist* describes a new instrument, termed the Scleroscope, which is intended for testing the hardness of metals. The instrument has been designed by the author of the article, who expresses his indebtedness to the French scientist, Dr. Paul Herould, for some valuable suggestions upon which its perfection largely depends It establishes, he claims, a scale for hardness, and determines the relative and quantitative hardness of all metals, including hardened steel. The author first carried out an investigation with a steel ball dropped in a glass tube from a given height. The object of this experiment was to find whether there was any difference in the height of the rebound of the ball from a piece of steel at spring temper, as compared with a piece glass hard. The difference was found to be slight and uncertain, although what little there was favoured further experiments, because spring steel gave less rebound than full hard steel. Several instruments were made on this principle, and although better results were obtained, much discouragement was encountered, because, although comparative hardness could be ascertained by the varying rebounds of the ball, quantitative measurements on steel, especially when hard, were most unsatisfactory. It was at this stage that the instrument was brought before the notice of Dr. Paul Herould, who at once appreciated the usefulness of such a contrivance. Dr. Herould's theory called for a drop hammer having a given weight and a fixed area at the striking point, which should bear such a relation to the weight that the hard steel would be slightly indented by the impact of the fall. Many experiments were made, and it was eventually found that it required a force of no less than 75,000 lb. per square inch to compress hard steel to a slight degree. Remarkable as it may seem, this great pressure could be obtained by dropping a hammer weighing only 40 grains from a height of 10in. by merely reducing the area of the point, and by making it convex at the tip. This scheme worked very well, except that at first trouble was experienced with the point flattening in spite of its hardness; this, however, was eventually overcome, and a successful instrument was constructed upon these lines.

The Scleroscope in its present state of evolution is shown in the accompanying illustration. It is provided with a nickelled hardened-steel anvil base, which is secured to a hard-brass tripod having three adjusting screws on the legs for levelling by means of a steel plumb bob. On the opposite side of the glass tube to the plumb bob there is a stay-rod which acts as a lens holder and also strengthens the tube case. The ball or plunger slides loosely within the graduated glass tube, and is returned to its starting position at the top by a small rubber suction bulb, which is pressed and then suddenly released. When the hammer is thus drawn to the top it is caught by a pin having a piston in a small cylinder, and a spring which serves to grip the hammer.

In making tests on small samples a steel clamp is used to hold them on the levelled base of the instrument. The glass tube is then raised or lowered to suit the height of the sample to be tested by a brass knob connected to a pinion which fits in a rack on the tube. To release the drop ball a small rubber bulb is pressed, while, at the same time, the tube case is pressed down upon the work by a yielding hook. The pressure on the bulb also opens an inlet valve to avoid the vacuum which would otherwise be formed by the drop of the plunger ball. When hard steel is struck the actual concussion is equal to about 30 lb. per square inch constant pressure, although the little ball weighs but 40 grains. With softer metals, this shock is more readily absorbed, and in lead the concussion is hardly more than one or two pounds per square inch. The author points out that he has found from long experience that the friction between the hammer and the sides of the glass tube is extremely small, and that it does not vary from time to time. In measuring lead the rebound is but 1½ per cent. of the ball, while in very hard steel it is 73, and over 85 per cent. for strong glass.

Elasticity can be measured with the Scleroscope by using a hammer with a comparatively large striking area, so that no appreciable dent is made. All readings are then considerably higher, although the curve will run approximately parallel to the hardness curve, having, as it were, the greatest deviations where the softening of hard steel does not alter its elastic properties. It is said that when equipped for testing hardness the instrument ignores the elasticity retained by hard steel which has been let down to a spring temper, and shows that, concordant with practical experience, this material is nearly 20 per cent. softer than full hard steel, or such as it was before it was let down. Like discriminations are said to be seen in other spring metals.

The action of the instrument is explained in several ways, and although the principle is fairly obvious from the foregoing remarks, some of the explanations given by the author may prove of interest. On the one hand, the height of rebound is determined by the power of resistance to penetration on the part of the metals tested; the greater the resistance the greater is the recuperative power of that metal, and the more will the hammer rebound. On the other hand, the action may be explained by presuming that the hammer falling from a fixed point has a certain amount of energy stored up in it which must give account of itself in doing work. If the metal which it strikes be soft most of the



THE SCLEROSCOPE

energy is spent in displacing metal and in heat, and little is left to repel the striking body, while if it is hard little work can be done in displacing metal, and little heat is generated, and, therefore, the surplus remains to exert itself on the hammer, and the hammer therefore rebounds to nearly the full height of the fall. In preparing the scale care has been taken to ensure uniform applicability to all metals in general use, so that the measurement of any one will at once show in numbers how it compares with hard steel or soft brass, which average about 100 and 10 respectively. Mr. Shaw gives a number of interesting results and tables in the original, but he leaves us in the dark as to how the rebound is measured. It would seem, however, that the position the hammer reaches has to be carefully watched and noted instantaneously. We should like to ask him if there is any material difference if the same spot in the test piece is struck several times in succession?

THE newly-electrified tramway line from Highbury to the Archway Tavern, Highgate, N., will be opened for traffic towards the end of the year.

LABOUR-SAVING APPLIANCES AT THE MINES OF THE NEW KLEINFONTEIN COMPANY, TRANSVAAL.*

By Mr. EDWARD J. WAY, Member, of Johannesburg.

DURING the late Boer War, on the morning of the 26th December, 1900, a raid was made by a commando of some 700 or 800 Boers against the property of the New Kleinfontein Company, and practically the whole of the surface equipment of the mine was destroyed by fire. Early in the following year the company decided to replace the old 160-stamp mill reduction plant by a complete new 200-stamp installation—Fig. 1 and Fig. 2—and the author received instructions to prepare the necessary designs and estimates. As at that time the prospect of obtaining a sufficient supply of unskilled coloured labour, both for immediate requirements and for the successful running of the mine, was an extremely doubtful one, the predominant factor in the entire design of the new surface equipment, and more recently of the underground equipment, was the replacement of coloured labour by the most up-to-date labour-saving appliances.

There is a point, of course, where the interest on the capital expenditure necessitated by the erection of a large mechanical plant, together with its maintenance and running costs, more than counterbalances any saving effected by the consequent reduction in the amount of unskilled labour employed; but so bad was the labour outlook at that period that the economics of the question were to a certain extent ignored, and the sole aim of the author was the substitution wherever possible, whether economically justified or not, of approved mechanical appliances in the place of unskilled coloured labour. Ample justification has been shown for the course pursued, not only in the large reduction in unskilled

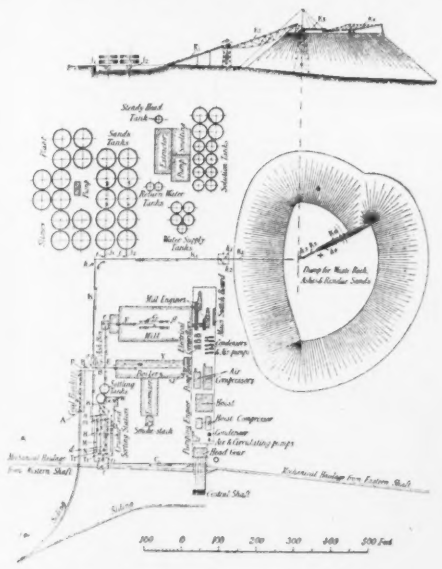


Fig. 1—NEW KLEINFONTEIN MINES

coloured labour effected, but also by the large actual saving in the working costs.

In pursuance of this design a branch line was constructed from the nearest railway up to the mine—Fig. 1—and the surface plant was equipped with a most complete system of conveyors and elevators for handling all coal, ash, ore, waste rock and residue sands, whilst more recently the stopes underground have been provided with swinging conveyors specially designed to permit the rapid and easy dismantling and re-erection necessitated by blasting requirements and by the constant shifting of the working faces of the stopes. In the following pages the above labour-saving appliances are briefly described, and an endeavour has been made to show the reduction which has been effected by their installation, both in the working costs and in the number of unskilled coloured labourers employed.

A branch line, with main sidings to the New Kleinfontein Company and to the other companies of the Kleinfontein group of mines, was immediately laid from the nearest available point on the main line between Johannesburg and Springs to the company's property, and before the material for the new plant began to arrive in the country the main siding to the company was completed and an off-loading station, equipped with a 30-ton Goliath crane, had been constructed close to the works complete with sidings running to the central engine-room, mill, crusher station, &c. It is difficult to estimate the reduction in the amount of unskilled coloured labour employed in transport and off-loading which resulted from the construction of this line, but it must have been considerable. Had the line not been laid out the whole of the material for the new plant must have been brought by bullock and mule-wagon transport from the nearest railway station, which would have necessitated it being off-loaded from the railway trucks to the wagons and again off-loaded at the mine by hand. The saving in the cost of handling and transporting this machinery alone more than covered the initial capital expenditure required to build the New Kleinfontein Company's share of the joint railway scheme, to say nothing of the additional capital expenditure that would have been incurred owing to the necessity, had the line not been constructed, of designing the machinery so that the weight of any single portion should not overtax the very limited capacity of the then existing transport arrangements. Moreover, since the plant has been running, it has resulted in a saving in the cost of the transport and off-loading of the material brought to the mine—which amounts on an average to about 4500 tons of coal, machinery, stores, &c., per month—of at least £12,000 a year, equal to a reduction in the working costs of about 7·4d. per ton milled.

* The Institution of Mechanical Engineers.

The coal and ash-handling plants, which were designed with the object of reducing to a minimum the employment of unskilled coloured labour in the steaming stations, are very complete. The coal is transferred from the railway trucks to the mechanical stokers of the boilers and superheaters, and the ashes are deposited on the main waste dump almost automatically. A siding from the company's branch line runs above the main coal bunkers, and the coal is delivered in 30-ton bottom-discharge trucks. Below the bunkers a Robins belt, 30in. wide and 102ft. long, runs at a speed of 150ft. per minute, and delivers the coal at the rate of 20 tons per hour to a pair of 17in. by 24in. crushing rolls with cast iron teeth. Here it is broken into 3in. cubes and, falling into the boot of an elevator of the open-running bucket type, is lifted a vertical height of 49ft., and discharged on to a Robins belt, 16in. wide and 245ft. long, which travels at a speed of 400ft. per minute, and deposits the coal in the overhead storage bunkers of the boiler-house by means of a tripper travelling automatically backwards and forwards for the full length of the building. From these bunkers, chutes deliver the coal as required to hoppers fitted to the chain-grate mechanical stokers of the boilers and of the independently-fired superheaters.

The ashes fall from the head ends of the travelling grates into small storage bins below the stokers, and are removed periodically by means of a motor-driven haulage running in a trench below the boiler-house floor. The skips are tipped automatically into the boot of an elevator of the enclosed bucket type, which raises the ashes a vertical height of 36ft., and deposits them in two ash storage bins. These bins are situated above the first section of the main waste belt, and their contents are discharged on to this belt once in twenty-four hours by means of adjustable chutes. The ashes are then carried by the belt on to the main waste dump.

With the old plant before the war the total amount of coal handled per month averaged 1500 tons, while at the present time the average per month is 3500 tons. Making allowance for this increased tonnage, the average number of unskilled coloured labourers required on the old plant in getting the coal—which was brought to the mine by ox wagon or traction engine—into the coal bunkers of the three steaming stations and in removing the residual ash, would have amounted at a conservative estimate to 71 per day, and in hand firing the boilers to 88 per day, while at the present time the average number employed per day on coal and ash-handling is 13, and in connection with the running of the

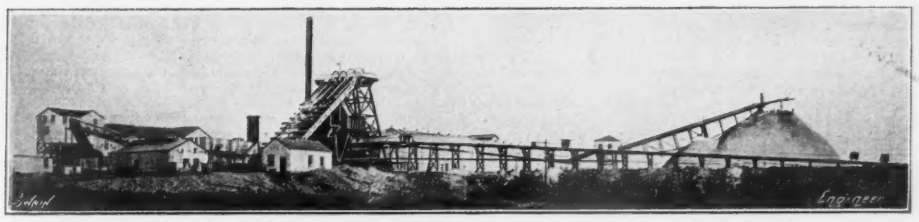


Fig. 2—GENERAL VIEW OF CONVEYOR PLANT

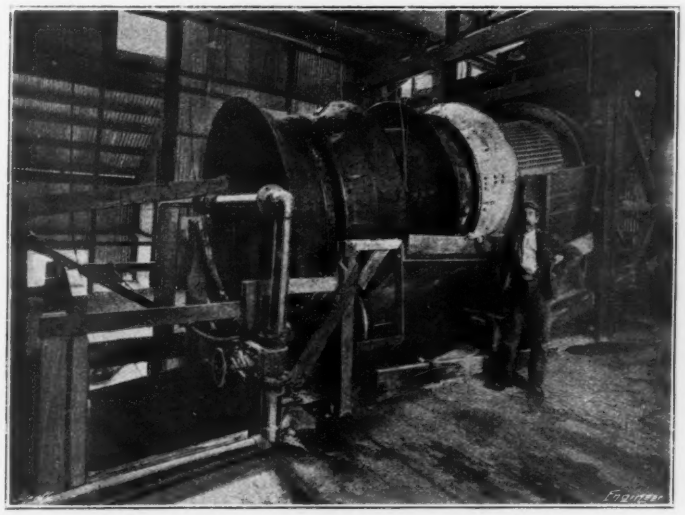


Fig. 3—MAIN TROMMEL AT THE CRUSHER STATION

mechanical stokers only eight. There is thus, as shown on Table I., a total reduction in the amount of unskilled coloured labour employed on coal and ash handling alone of 138 men.

Over and above this reduction in unskilled labour there has been an unknown but considerable saving in maintenance costs, due to the introduction of mechanical stoking. For the two and a-half years during which the plant has been running, it has not been found necessary to renew a single boiler tube; while it is within the author's knowledge that, in an almost identical boiler plant by the same makers erected about the same time but arranged for hand firing, there has been constant trouble with the water-tubes, due to the large variation in temperature and the consequent contraction and expansion of the tubes caused by the rush of cold air through the boilers on opening the fire-grate doors for hand firing. Quite recently these boilers have had to be taken down and the joints between the boiler shells and the water legs re-riveted, as the varying strains on these joints, due to the constant expansion and contraction of the water tubes, had begun to weaken them and to render them unsafe.

The installation of mechanical stokers has, moreover, resulted in an actual saving in the total capital expenditure on the steaming station. When the plant was erected ten boilers only were installed, but provision was made for the extension of the boiler plant, which it was thought would be required when the full battery of 200 stamps was running. Owing, however, to the extreme reliability of the boilers under mechanical stoking, it has been found unnecessary to have more than one stand-by boiler, enabling the other nine boilers to be worked full time. With hand firing at least three boilers would have been required as stand-bys, thus necessitating the erection of two additional boilers. Moreover, with mechanical firing the number of pounds of coal burned per square foot of grate area is about 33 per cent. more than with hand firing. If the mechanical stokers had not been put in, it would have been necessary to keep twelve boilers constantly under steam instead of nine as at present, thus bringing up the total number of boilers, including the three stand-bys above mentioned, to fifteen. The increased capital cost of these five additional boilers, without taking into account the cost of their foundations and erection, and the extra cost of the necessary extension of the boiler-house, storage bunkers, conveyors, &c., would far exceed that of the existing stoker plant.

All the ore stoped underground and hoisted to the surface through the three shafts which serve the company's property, and which are known as the "East," "Central," and "West" shafts, is brought to the main ore bins of the headgear at the Central shaft. A mechanical haulage from the ore bins of the headgears at the East and West shafts conveys the ore hoisted through those shafts in a haulage ore bin to the main ore bin at the Central shaft headgear. From this point a system of conveying belts handles the ore almost automatically on its course through the reduction plant, and finally deposits the waste rock and residue sands—as well as the ash from the central steaming station—on the main waste dump.

The conveying plant falls naturally into two sections, that transferring the ore from the headgear ore bins at the Central shaft to the crusher station and mill, and that removing the waste rock and the residue sands to the main waste dump. The first section comprises the conveyor from the central headgear ore bins to the crusher station, the sorting and conveying belts within the crusher station, and the system of belts conveying the "fines" from the crusher station to the mill and distributing them in the mill bins. The second section consists of the main waste belt to the dump and the subsidiary belts feeding on to the main waste conveyor, and carrying the waste rock from the waste rock bins of the crusher station and the residue sands from the sand treatment tanks of the cyanide plant.

The conveyor carrying the ore to the crusher station first passes horizontally immediately below the feeder chutes of the central

Reference Table to Fig. 1.

Mark.	Description.	Belt conveyors, &c. Width.	Centres.	Speed.	Capacity.	Inclination.	Lift.	Motors. Mark.	H.P.
		In.	Ft.	Ft. per min.	Tons-hour	Degrees.	Ft.		
A	Under main coal bunkers	30	102	150	20	Horizontal	—	a	50
B	Distributing coal conveyor	16	245	400	20	,,	—	a	50
C	Head gear to crusher station	30	178	200	280	35	47	c	50
D	Return intermediate conveyor	18	79	300	50	21·5	30	d	15
E	Crusher station to mill	24	365	350	168	18	58	e	50
F	Fines conveyor in mill	20	180	280	168	Horizontal	—	e	50
G	Shuttle belts over mill bins	20	84	348 carriage, 12	168	,,	—	g	7½
H	Waste rock under bins	30	52·5	260	112	,,	—	h	50
J_1 & J_2	Residue sands under tanks	18	185·5	486	170	,,	—	j	15
K	Waste rock and ashes	30	434	275	116	,,	—	k	50
K_1	Waste rock, ashes, and sands	30	355	295	284	19·5	70	k_1	50
K_2	Waste rock, ashes, and sands	30	197	320	284	18	58	k_2	50
K_3	Distributing waste conveyor	30	60 (increased to 140	340	284	Horizontal	—	k_3	10
K_4	Cantilever waste conveyor	30	160	340	284	5 and 10	21	k_4	15
M	Coarse sorting belts	36	86·5 sorting, 60	50	58	15 and sorting, 10	16·5	m	7½
N	Intermediate sorting belts	36	98·5 sorting, 60	50	61	,,	18·5	n	7½

P	Coal crushing rolls. 17in. × 24in. Same drive as for "A."
R	Coal elevator. 49ft. lift. Same drive as for "A."
S	Ash elevator. 36ft. lift. Driven off 25 horse-power motor "s 1."
T	Main screening trommels. Same drive as for "C."
T_1	Secondary screening trommels. Driven off motor "t_1."
T_2	Screening trommel, for conveyor "D." Same drive as for "D."
V	Crushers.
W	150 horse-power motors (one stand-by) for crushers.
Y	Mechanical haulage for ashes, driven by steam winch.
○	Starting point, from bins of head gear.
+	Finishing point, at dump.

TABLE I.—*Unskilled Coloured Labour Employed in Coal and Ash Handling.*

Nature of employment.	Employed on old plant, on basis of tonnage handled at the present time.	Employed on present plant.	Reduction in number of unskilled coloured labourers employed.
Handling coal and ash	71	13	58
Stoking	88	8	80
Total reduction in unskilled coloured labour			138

headgear ore bin, and then, after curving round an arc of a circle of 250ft. radius, runs upwards at an angle of 15 deg., raising the ore a vertical height of 47ft. and delivering it direct to the main trommel in the crusher station. This conveyor—a Robins belt 30in. wide and 278ft. long between pulley centres—handles an average of 1760 tons of ore per day, and, when running at its normal velocity of 200ft. per minute, has a carrying capacity of 280 tons per hour. It is driven at its head end by a 50 horse-power motor, which, like all the motors driving the various conveying belts on the plant, is of the slow-speed, back-geared, enclosed type. The speed of these motors is between 580 and 600 revolutions per minute, geared to give a speed to the lay shaft of 160 revolutions per minute. Each motor is fitted with a speed-controlling switch capable of regulating the speed from 25 per cent. below normal—by means of resistance inserted in series with the armature—to 25 per cent. above normal, by means of resistance inserted in series with the field magnet winding.

The main trommel, Fig. 3, 18ft. long and 5ft. in diameter, is inclined at an angle of 10 deg., and runs at 10 revolutions per minute, driven through a chain and sprocket-wheel drive and spur gearing by the 50 horse-power motor driving the conveyor carrying the ore to the crusher station. The upper half of the trommel acts as a screen and removes some 40 per cent. of the total ore brought to the crusher station, or an average of 704 tons per day, which falls as "fines" direct into the No. 1 "fines" bin; while the lower half acts as a washer, and, by removing dust and dirt from the remaining 60 per cent. of rock, facilitates its sorting on the sorting belts. The cleansed rock passes direct to two revolving screens 10ft. 6in. long, and 3ft. 6in. in diameter, inclined at 11 deg. to the horizontal and driven at 12 revolutions per minute by a 20 horse-power motor. Here it is separated into two sizes, all under 3in. cubes—some 40 per cent. of the total—passing as "intermediates" direct to the two "intermediates" sorting belts, and the remaining 60 per cent. passing direct to the two "coarse" sorting belts. On the "coarse" belts about 40 per cent. of the rock is sorted out as waste, while the remainder, falling over the head ends of the belts on to the chutes, is delivered directly to the "coarse" crushers and is broken into 3in. cubes, which drop on to grizzly bars spaced 1in. apart. About 10 per cent. of the broken rock falls between the bars into the No. 2 "fines" bin, and the remaining 90 per cent. is conveyed as "return intermediates" by the "return intermediates" belt to the "return immediates" trommel. This trommel, which is driven at 10 revolutions per minute by the 15 horse-power motor driving the "return intermediates" belt, is inclined at an angle of 10 deg., and is 4ft. long by 3ft. in diameter. It acts simply as a washer, and, after cleaning the "return intermediates" from dust and dirt, discharges them to join the "intermediates," separated by the two revolving screens previously mentioned, with which they pass direct to the "intermediates" sorting belts. There they undergo a second sorting, in which the 20 per cent. of waste still left in the "return intermediates" is picked out, bringing up the total waste rock removed from the "coarse" to 50 per cent., while at the same time an average of 50 per cent. of waste is sorted out from the "intermediates." The ore remaining on the "intermediates" belts passes direct to the "intermediates" crushers, where it is broken into 1in. cubes and is deposited in the No. 2 "fines" bin. The total waste rock sorted out averages 50 per cent. of the ore sent to the sorting belts, or 30 per cent. of the total ore mined and brought to the crusher station, and amounts on an average to about 528 tons per day.

The "coarse" and "intermediates" sorting conveyors proceed, at an inclination of 16 deg., from the chutes which catch the "coarse" and "intermediates" separated by the revolving screens, and which feed them on their respective sorting belts, up to the sorting floors situated above the waste rock bins, and pass at an angle of 10 deg. over these floors to their head ends, where they discharge the concentrated ore on to the chutes leading to the crushing plant. All four conveyors are Robins belts, 36in. wide, and each is driven at a normal speed of 50ft. per minute by a 7½ horse-power motor geared to its head pulley. The two "coarse" belts are 86ft. 6in. long between pulley centres, and each has a capacity of 58 tons per hour, while the two "intermediates" belts are 98ft. 5in. long between pulley centres, and each has a capacity of 61 tons per hour.

The "return intermediates" conveyor—a Robins belt 18in. wide and 79ft. 2in. long between pulley centres—runs upwards between the waste rock bins at an angle of 21½ deg., and extends from the grizzlies below the "coarse" crushers up to the "return intermediates" trommel. It is driven at its head end by a 15 horse-power motor at a speed of 300ft. per minute, and has a carrying capacity of 50 tons per hour. (This angle of 21½ deg. appears to the author to be the critical angle for conveyors of this type of handling rock of this size.)

The average tonnage handled per day by the various belts is as follows:—317 tons by each "coarse" belt, 382 tons by each "intermediates" belt, and 342 tons by the "return intermediates" belt; while an average of 528 tons of "fines" is deposited in the No. 2 "fines" bin, which, with the 704 tons screened out by the main trommel and deposited in the No. 1 "fines" bin, brings the average daily tonnage crushed and concentrated in the crusher station ready for conveying to the mill bins up to 1232.

The system of conveyors transporting the "fines" from the crusher station to the mill bins comprises three distinct sections; the first, consisting of a belt from the crusher station to the mill; the second of a belt running along the top of the mill; and the third of two "shuttle" belts distributing the "fines" in the mill bins. The first conveyor, a Robins belt 24in. wide and 365ft. long between pulley centres, runs under the full length of the crusher station, sloping downward at an angle of 5 deg. from below the feeder chutes of the No. 1 "fines" bin to below the feeder chutes of the No. 2 "fines" bin; and, between these two bins, passes under the conveyor feeding the waste rock from the waste rock bins of the crusher station on to the first section of the main waste conveyor to the dump. After passing below the No. 2 "fines" bin the conveyor bends rounds a curve of 250ft. radius, and on reaching the ground level is continued upwards at an angle of 18 deg., raising the "fines" a vertical height of 58ft. and feeding them direct on to the second conveyor. It is driven at its head end by a 50 horse-power motor at a speed of 350ft. per minute, and has a normal carrying capacity of 168 tons per hour. The second conveyor is a Robins belt, 20in. wide and 130ft. long between pulley centres, and runs first horizontally at right angles to the first belt for a distance of 70ft., passing through a weighing room and out above the mill bins, and then, curving round an arc of a circle of 250ft. radius, rises upwards a vertical height of 12ft. to its head end above the centre of the length of the bins. It is driven at its tail end at a speed of 286ft. per minute by the 50 horse-power motor driving the head end of the first belt, and has a normal carrying capacity of 168 tons per hour. In the weighing-room the "fines" are automatically weighed and the weight registered by means of a Blake-Denison weighing machine. The principle upon which this machine is constructed is that of weighing a fixed length of the belt at intervals of time corresponding to the travel of such length. In this case a 30ft. length of the belt is weighed at intervals of approximately 6·29 seconds. This machine and a similar one in connection with the waste-rock belt have given complete satisfaction, as the margin of error is very small indeed, not exceeding ½ to ¾ per cent. The "fines" falling over the head end of this belt drop on to a double discharge chute and are fed on to two "shuttle" belts, each of which is a Robins belt 20in. wide and half the length of the mill bins, or 84ft. long between pulley centres. These belts, which are situated one on either side of, and parallel to, the second "fines" belt, are supported by a carriage running on a double track of rails 164ft. long laid on the bin caps. As the carriage runs backwards and forwards along the track the "shuttle" belts deposit the "fines" alternately in the two end halves of the mill bins. The belts and carriage are driven by a 7½ horse-power motor, the carriage at 11·6ft. per minute, and the belts at 348ft. per minute, the direction of travel of both belts and carriage being the same, and both being reversed simultaneously at each end of the mill bins. The average tonnage handled per day by the system of "fines" belts amounts to about 1232.

(To be continued.)

THE INSTITUTION OF CIVIL ENGINEERS.

TRANMERE BAY DEVELOPMENT WORK.

At the ordinary meeting on Tuesday, 26th November, Sir William Matthews, K.C.M.G., president, in the chair, the paper read was "The Tranmere Bay Development Works," by S. H. Ellis, M. Inst. C.E. The following is an abstract of the paper:—

The works described comprise two graving docks, two floating basins, launchways, engineering shops, and other equipment of a new shipbuilding yard, together with the continuation of two town sewers. These subjects are dealt with under the following heads:—

(1) *Reclamation.*—The works are situated on what was tidal foreshore of the river Mersey, and the first step in their construction was the reclamation of the site. This was effected by a series of three dams: (*a*) A timber cofferdam, 625ft. in length, and about 36ft. in height above the foreshore; (*b*) a temporary concrete wall, 250ft. in length and 29ft. in average height; and (*c*) a clay embankment extending between low and high-water mark. The construction of the cofferdam is described in some detail, and also the measures taken to remedy a temporary breach of part of the clay dam.

(2) *Sewers.*—The form of construction of the larger of the two sewers—a culvert 6ft. 6in. in diameter, constructed by tidal work during the period of reclamation—is briefly described.

(3) *Graving docks.*—These are respectively 708ft. and 861ft. in effective length, and are largely cut out of the sandstone rock, with concrete walls above the surface of the rock (on one side only just above dock bottom), or where the rock was defective in character. The entrances are closed by floating ship caissons, which are briefly described, as are also the pumping appliances.

(4) *Basins.*—The outer floating basin, the entrances of which are closed by gates, is 15 acres in area, with a depth of water of 31ft. 7in. at high water of ordinary neap tides. The quay walls, respectively 1000ft., 850ft., and 990ft. in length (besides a frontage wall 460ft. in length), are of concrete throughout. Some account is given of the forward movement of part of the longest wall, which is founded on sand, with bearing piles driven down to rock. The inner basin, entered from the outer, is for shallow draught vessels, and is 2⅜ acres in area.

(5) *Concrete.*—The materials and methods of manipulating the concrete are briefly dealt with.

(6) *Equipment.*—The principal items of equipment are mentioned, together with some details of the power station for generating electricity by means of gas engines and dynamos.

(7) *Shop foundations.*—A description is given of the Simplex system of concrete piling, largely used on these works for the column foundations of heavy engineering shops situated on made ground.

(8) *Launchways.*—The method of forming the launchways and shipbuilding slips is described, and an account is given of the form of construction of the frontage-wall (which is founded on concrete piers sunk through 30ft. to 35ft. of silt to the rock) by grabbing from the centre of (*a*) wrought-iron caissons, (*b*) hollow concrete monoliths on an iron cutting edge.

(9) *Dredging.*—Mention is made of the methods employed in dredging about 64,000 cubic yards of rock and silt from the foreshore in front of the entrances.

The Institution of Civil Engineers: Association of Yorkshire Students.—The Parkgate Iron and Steel Company, Limited, Rotherham, has kindly consented to allow members to visit its works on the afternoon of December 20th. Members wishing to join the party are requested to communicate with one of the honorary secretaries before December 10th. The visit will be abandoned unless a sufficient number signify their intention of taking part in it.

Professorship of Engineering at Oxford.—We are informed that the sums required for starting the Professorship of Engineering at Oxford have now been raised. For initial expenses £951 have been subscribed, £500 of this coming from Merton College, and £200 from the Common University Fund, this being contingent on the remainder of the sums estimated as necessary, namely, £700 a year, and a capital sum of £800 being guaranteed from other sources before the end of the present year. A sum of £885 a year has been further guaranteed jointly from a number of sources, including New College, this being for maintenance purposes.

Physical Society Exhibition.—At the exhibition to be held by the Physical Society on Friday evening, December 13th—from 7 p.m. to 10 p.m.—at the Royal College of Science, South Kensington, the following firms will be exhibiting: Messrs. R. and J. Beck, Limited; Cambridge Scientific Instrument Company, Limited; Casella and Co., A. C. Cossor, Crompton and Co., Elliott Brothers, Everett, Edgcumbe and Co., Evershed and Vignoles, Limited; Clark, Fisher and Wadsworth, Gambrell Brothers, J. J. Griffin and Sons, A. Hilger, Limited; Leslie Miller, Nalder Brothers and Co., Nalder Brothers and Thompson, Limited; Newton and Co., R. W. Paul, James Pitkin and Co., Ross, Limited; Alexander Wright and Co., and also the Meteorological Office. From the programme, of which we have received an advance proof, there appear to be many items of considerable interest to both physicists and electrical engineers.

The Imperial College of Science and Technology.—The Earl of Crewe, chairman of the Governing Body of the Imperial College of Science and Technology, has authorised the publication of the following communication:—The Governing Body of the Imperial College of Science and Technology have appointed three standing committees, a Finance Committee (chairman, Sir Francis Mowatt), an Education Committee (chairman, Mr. Arthur Acland), and a General Purposes Committee (chairman, Lord Halsbury). In addition, they have appointed two temporary committees, a Transfer Committee (chairman, Mr. Arthur Acland), and an Organisation Committee (chairman, Mr. Gerald Balfour; vice-chairman, Sir William White). Matters relating to the transfer to the Imperial College of the constituent institutions, which it has been arranged shall take effect as from the 1st January next, and to the transfer of land from the Exhibition Commissioners, have been referred to the Transfer Committee. The Organisation Committee, to which have been referred matters relating to the future organisation of the Imperial College, have appointed four sub-committees to consider questions arising under this head in relation to the following sciences or groups of sciences, viz.:—(1) Mining and metallurgy (chairman of the sub-committee, Sir Julius Wernher); (2) other branches of engineering (chairman, Sir John Wolfe Barry); (3) biological sciences (chairman, Sir Archibald Geikie); and (4) other pure and applied sciences (chairman, Sir Arthur Rücker). The Governing Body have authorised the appointment of persons not members of the Governing Body who are specially conversant with the sciences in question, or with their industrial applications, as additional members of these sub-committees, which are now engaged in considering the questions referred to them. The Governing Body have also approved in principle the appointment of a principal officer of the Imperial College, and have referred the question of his title and functions to the Organisation Committee.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Decline in Pig Iron Prices.

Crude iron quotations have been in several instances materially reduced in order to bring out further business, this course being taken by producers, who are coming to the end of their present contracts, and who are anxious about the early future. Some sellers are understood to be willing to accept reductions of as much as 3s. or 4s. upon recent rates. Quite a general figure for Northampton iron is now 53s., and, indeed, 50s. is talked of, a level which has not been heard of for some two years past. Derbyshire forge iron is quoted 54s. and 55s., and some descriptions of Staffordshire are 53s. to 53s. 6d. Purchasers are buying only from hand to mouth, and stocks both in their own and in makers' hands are practically non-existent. There seems some uncertainty as to the outlook, among the possibilities being a recurrence of American dumping in the spring.

Manufactured Iron.

Marked bars are quoted £9, with the Earl of Dudley's brand £9 12s. 6d., the second grade of the "list" houses being £8. A fairly good demand is experienced for unmarked bars at £7 2s. 6d. to £7 7s. 6d., and North Staffordshire sorts are £7 10s. Plain sheet makers find business quiet, and quote singles £8 to £8 5s.; doubles, £8 2s. 6d. to £8 7s. 6d.; and trebles, £8 15s. to £9. Galvanised corrugated sheets of 24 gauge f.o.b. Liverpool are £13 2s. 6d., with a good foreign demand from South America, India, and Australia. Spelter is in only small inquiry, hard qualities being quoted £17 12s. 6d. at stations in the Birmingham district. Rivet iron is quoted £7 15s.; slit nail rods, £8 10s.; gas strip, £7 10s. to £7 12s. 6d.; and hoop iron, £8 5s.

A Moderate Demand for Steel.

There is a limited inquiry for semi-finished steel, with Bessemer billets quoted £5 7s. 6d., and Siemens £5 10s. German competition is being increasingly felt. With regard to sections, an improvement in the carriage and wagon building industries is occasioning an improved demand for angles, channels, and plates, and quotations are sustained at: Angles, £6 15s.; girder plates, £7 5s. to £7 15s.; mild bars, £7 10s. to £7 15s.; and boiler plates, £8 12s. 6d. to £8 15s.

Mines Drainage Commissioners.

With regard to the progress of operations in connection with the South Staffordshire Mines' Drainage Commissioners, Mr. E. B. Marten reports with reference to the surface works that in the Tipton district the Moxley stream has been raised where swagged. Great efforts have been made to prevent acid water from coming into the watercourses, and thence into the canals. In the Kingswinford district a long-promised and good permanent work has been effected by making a direct channel into the canal jointly with others, which provides a safe outlet for water pumped by the Stourbridge Glazed Brick and Fireclay Company's engine. In the Old Hill district another long-promised work is being done in diverting the water from the locality of the old Gad's Green reservoir into the canal at Bumble Hole. Mr. Edmund Howl, engineer to the Tipton district, reports as to that district that the rainfall during the four weeks has been 2·44in. The pumping and tanking has been 9,132,000 gallons per twenty-four hours, compared with 9,138,000 gallons the previous month, and 9,030,000 gallons in the corresponding period of last year.

Wolverhampton Tramways.

The Wolverhampton Town Council have approved the clauses relating to tramways in the draft of a bill which it is proposed to promote in the next session of Parliament, mainly to secure an extension of time for tramway construction, including the completion of the Lod-road route.

Birmingham Tramways.

Mr. Alfred Baker, the general manager of the Birmingham Corporation Tramways, has delivered an address before the Birmingham and Midland Institute Scientific Society strongly advocating the overhead tramway system as compared with the conduit system, chiefly on the ground of economy. The London County Council Tramways, on the conduit system, after providing for interest and sinking fund, left a net balance of less than £10,000 on a turnover of nearly a million and a-half sterling. In Birmingham, on the overhead system, where the traffic could not, of course, compare at all with London, it was expected that the profits would far exceed that amount on about one-sixth of the London capital expenditure. In his opinion, the overhead system was by far the best in every respect, except perhaps from the æsthetic point of view. Of the three chief methods of overhead construction, the span wire system, adopted by Birmingham, was, he considered, far superior to the other methods. It was certainly neater, and it gave steadier running. He announced that new brakes were under test.

Electric Supply Improvements.

The Birmingham City Council on Tuesday passed a resolution authorising their Electric Supply Committee to provide additional electric plant at an estimated cost of £231,285, and instructing the Finance Committee to borrow that amount. The Electric Supply Committee showed that in 1908 they would have to deal with a maximum demand of 11,660 kilowatts, while the capacity of their plant—after changes now recommended at Dale End—would be 14,740 kilowatts. The Committee have, however, made a forecast of their requirements for the next three or four years. It is proposed to discontinue Dale End as a generating station owing to the greater economy which can be effected in the distribution of boiler power, with the greater room at Summer-lane. The generating cost at Summer-lane is only 0·284d., as compared with 1·5d. at Dale End. Dale End will be available as a sub-station for storing and distributing power, and will provide accommodation for motors on hire testing purposes, and extra offices. The margin of capacity at Summer-lane under this arrangement is as small as is consistent with safety, and leaves no margin for progressive development. It is such development that the Committee have now to consider, and they assure the Council that although a comprehensive schedule of new plant is presented, it will only be erected in accordance with the Committee's experience of the increased demand which is anticipated. The amount expected to be required for next year is £99,000, when some of it—£60,000 or £70,000—will probably be wanted about November or December, leaving the remainder for 1909. The expenditure up to the present time has, the Committee intimate, been remunerative and is expected to continue so.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

Manchester, Wednesday.

Pig Iron Market Disorganised.

It is difficult to write with certainty as to the condition of the pig iron market during the past week. The Lincolnshire Association took what is thought here to be the extraordinary, as well as unnecessary, course of reducing No. 3 foundry 6d. per ton. Why this should have been done when merchants were freely quoting 2s. per ton under the official price it is difficult to say. It has been practically of no use to the trade. Hematite iron was

thought to have touched "bottom," but as compared with last week, it is fully 1s. 6d. per ton lower, and the prospects are far from bright. Derbyshire is most variable of all, and reports on Tuesday's Iron 'Change indicated a serious drop. Even makers' representatives were bound to admit that trade was very dull, and for delivery early in the year fair concessions would be made for quantity. Staffordshire was also a shilling or so lower; but Middlesbrough open brands, notwithstanding the erratic course of warrants, were steadier than might have been expected under the circumstances. No doubt the heavy shipments have something to do with this, but so far as this centre is concerned, buyers are still holding off except for pressing requirements. Forge iron is in poor request.

Finished Iron.

One prominent merchant informed us that business in this department had fallen flat indeed, and was almost the weakest point in the market. Orders of any weight were very scarce.

Steel.

Several makers reported a fair business in some sorts of structural and similar work, but foreign billets were offering at low prices. The principal makers in Lancashire are, however, placing their output at fair rates.

Copper.

There was little or no change to note in manufactured stuff.

Quotations.

Pig iron: Lincolnshire No. 3 foundry, 59s. 6d.; Staffordshire, 57s. 6d.; Derbyshire, 58s. 6d.; Middlesbrough, open brands, 57s. 6d. Scotch: Gartsherrie, 67s. 9d.; Glengarnock, 68s.; Eglinton, 64s. 9d.; Dalmellington, 64s. 3d., delivered Manchester. West Coast hematite, 67s. 6d.; East Coast ditto, 69s., both f.o.t. Scotch, delivered Heysham: Gartsherrie, 65s. 6d.; Glengarnock, 65s. 9d.; Eglinton, 62s. 6d.; Dalmellington, 62s. Delivered Preston: Gartsherrie, 66s. 9d.; Glengarnock, 67s; Eglinton, 63s. 6d.; Dalmellington, 63s. 3d. Finished iron: Bars, £7 10s.; hoops, £8 2s. 6d.; sheets, £8 5s. Steel: Bars, £7 5s. to £7 15s.; hoops, £8 2s. 6d.; sheets, £8 15s.; boiler plates, £8 12s. 6d.; plates for tank, girder, and bridge work, £7; English billets, £5 5s. to £5 10s.; foreign ditto, £4 15s. to £4 17s. 6d. Copper: Sheets, £80; tough ingot, £68 to £69; best selected, £65 per ton; copper tubes, 10½d.; brass tubes, 8½d.; condenser, 9½d.; rolled brass, 7½d.; brass wire, 7½d.; brass turning rods, 7d.; yellow metal, 7½d. per lb. Sheet lead easier at £20 15s. per ton. English tin ingots lower, being now £135 per ton.

The Lancashire Coal Trade.

There was a good attendance on the Coal Exchange, but merchants were not inclined to operate to any great extent. Still, the feeling in shipping was reported slightly better. House coal was quiet, but slack remains firm, and in good consumptive request.

BARROW-IN-FURNESS, Thursday.

Hematites.

The business being done in the hematite iron trade is very quiet. Makers are not able to do much trade either in prompt or forward deliveries, although transactions in both classes are being made on a modest scale. The needs of the market are indeed few, and the prospects of improvement are somewhat remote. There has been a falling off in the demand from all sources, and this has been most marked in the smaller requirements of local and other makers of steel, who usually require a large delivery of hematite iron when they are doing a good business. Quotations are somewhat weaker. Mixed Bessemer numbers are at 69s. per ton net f.o.b. nominally, and warrant iron settlement price is 67s., while deliveries in three months are at 66s. 6d. net cash. On a rising market prices are always higher for forward deliveries, and on a falling market the opposite. This is proof that those who know the trade best are apprehensive of a still quieter state of things. Orders are not well held by makers, and the production of iron is very low, yet stocks do not increase. Warrant stocks now stand at 6482 tons, the same as last week, and makers' stocks are very slight. A smaller business is being done in special hematites and in spiegeleisen and ferro-manganese. Iron ore is in limited demand, and good ordinary native sorts are selling at 14s. net at mines.

Steel.

There is no improvement to note in the steel trade. The demand for railway material, which is the chief production of the district, is very small, and there are very few specifications in the market of any size, although prices have come down somewhat, heavy rails being at £6 6s. per ton net f.o.b. There are prospects of better times in shipbuilding material, but at present makers have very few orders in hand. Merchant steel is very quiet, and there is not much business being done in heavy foundry steel for shipbuilding and engineering purposes.

Shipbuilding and Engineering.

No new orders have been secured for new shipping tonnage, but prospects are brighter than they have been; but when competition is so keen it is difficult to estimate where the few orders in the market are likely to be placed. Engineers are also expecting some new orders, and in the meantime are very busy.

Shipping and Coal.

The shipping trade remains inactive. The exports of iron last week amounted to 4181 tons, and of steel to 5575 tons, a total of 9756 tons, against 11,499 tons in the corresponding week of last year, a decrease of 1743 tons. The shipments of the year to date have reached 785,357 tons, as against 757,209 tons for the corresponding period of last year, an increase of 28,148 tons. Freights are lower. Coal and coke are declining in prices gradually week by week, as the demand falls away.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Business Position.

THE situation in this district has not materially changed, except that there is a further reduction in the prices of Lincolnshire irons locally used, as well as in Derbyshire foundry and forge. In the heavy industries generally fresh orders would be very welcome, in marine and military material especially. The manufacturers of railway rolling stock continue to be most satisfactorily employed, and steady business is reported, the work in hand being largely for foreign and colonial markets, and the home companies have also been affording more employment for makers of railway material. It is expected that their requirements will get considerably heavier later on. The coal trade remains firm, the prolonged export business being an important factor in the situation.

House Coal.

The weather continues very variable, and expectations of any general reduction in household fuel have not been, or are likely to be, realised. Christmas is too near, with its accustomed holidays, to admit of easier quotations being established. A fairly brisk business is being done both on local and distant account. Coalowners recognise no call to revise lists at this advanced season of the year. Best Barnsley is quoted at 13s. 6d. to 14s. 6d. per ton; secondary qualities, from 12s. to 12s. 6d. per ton.

Steam Coal Still Active.

The export business is well maintained, both with Hull and Grimsby. Although the figures of exports from both ports are again considerably higher than for the corresponding period of last year, the trade cannot be continued much longer on this level, and the shrinkage of business with the upper Baltic ports is getting more evident. Considering the advanced season, however, the foreign requirements are exceedingly well maintained. From Hull, for the week ending 26th November, the total exports were 80,596 tons, compared with 54,686 tons for the similar week of last year. The Swedish port of Oxelösund received the heaviest weight, 11,989 tons, Buenos Ayres coming next with 4302 tons. From Grimsby, for the week ended November 29th, the exports to foreign destinations amounted to 34,810 tons, against 28,197 tons for the corresponding week of last year. Gefle was first with 7532 tons, and Hamburg next with 5578 tons. During the same week the coastwise trade from Grimsby fell to 1031 tons, from 2026 tons for the similar period of last year. There is nothing fresh to report in regard to the trawling and supplementary railway contracts, which fall out at the end of the year. Values are firmly maintained, Yorkshire hards making, in the open market, from 12s. 6d. to 13s. per ton at the pit.

Coke, Coking, Slack, and Manufacturing Fuel.

Coke is again somewhat weaker, best washed being this week quoted at 13s. to 14s. per ton, and unwashed 12s. to 13s. per ton. These figures show a reduction of 6d. per ton on those given in last report. The weakening is through the lessened call for small coal for the Lancashire and Yorkshire textile districts, thus temporarily increasing the output of coke beyond the market requirements. The best qualities of slacks for steam-producing purposes are at former figures—6s. 6d. to 7s. per ton.

Hematites.

Affairs remain pretty much as previously reported, and quotations are unaltered; for delivery at Sheffield and Rotherham, West Coast remains at 86s. 6d. to 88s. 6d. per ton; and East Coast at 82s. 6d. to 84s. 6d. per ton, East Coast subject to 2½ per cent.

Another Reduction in Lincolnshire Irons.

At their meeting, last Friday, the Lincolnshire Ironmasters' Association reduced their quotations for the iron largely used in this district to the following prices:—No. 3 foundry, 55s. 6d. per ton; No. 4 foundry, 55s. per ton; No. 4 forge, 54s. 6d. per ton; No. 5, mottled, white, and basic, 55s. 6d. per ton. These figures, as compared with those given last week, exhibit a drop of 6d. per ton in No. 3 foundry, of 1s. per ton in No. 4 foundry, of 1s. 6d. in No. 4 forge, and of 2s. 6d. per ton in No. 5 mottled, white, and basic. The reduction has, no doubt, been made with the object of inducing purchasers to come into the market and buy in quantities for next year. What is now being bought is for immediate delivery. The position is somewhat peculiar, for with pig iron very scarce prices are being reduced. More business, though in no great quantities, has been done, but it has been to meet current requirements.

Derbyshire Irons, &c.

Another reduction of 1s. a ton is reported in Derbyshire No. 3 foundry and No. 4 forge, which are now quoted at 58s. and 56s. per ton respectively. While there is considerable pressure for early deliveries, we hear of additional business being done for forward account. Bars remain at the lower rate given last week, £7 10s. to £8 per ton; sheets, £10 10s. per ton; Bessemer billets, £8 5s. per ton; Siemens billets, £8 15s. per ton.

Steel.

The reports respecting the steel trade generally are not so gratifying as during the earlier months of the year. There has been much less done with the United States in special steels, including high-speed tool steels, and the demand from several other markets has not quite equalled expectations. In the lighter steel trades the department most actively employed is the manufacture of files, and there are excellent prospects of the good business being maintained. A fair trade is reported in engineering tools generally, although there is not probably so active a request as was the case some months ago. Tenders for the supply of tools for the royal dockyards will, it is expected, be invited shortly.

Railway Work.

This department continues to be steadily employed, with every prospect of the works engaged in it being kept busy for a considerable time. The orders are chiefly for India, Australia, and South America, and the outlook in all these markets is most encouraging. More work is being placed by home companies, though not to the extent that was anticipated when the labour troubles terminated.

The Christmas Trade.

Some disappointment is expressed with regard to the lighter staple industries. The season business in cutlery, silver, and plated goods, to meet the special requirements of Christmas and the New Year, opened out very hopefully, but in several quarters it is reported that the early promise has not been maintained. It is difficult to get at the actual condition of affairs, as reports differ very materially. Some of the establishments have been satisfactorily engaged in most departments, and a good deal more money has been paid in wages than was the case last year. In other directions less gratifying reports are given; but it is to be hoped, when the work of the twelvemonth comes to a close, that the results will not prove so disappointing as some people appear to anticipate.

NORTH OF ENGLAND.

(From our own Correspondent.)

Shipbuilding.

THE shipbuilding industry is feeling the falling off in trade more intensely than any other branch of business carried on on this North-East Coast; the depression in it becomes more pronounced every week, and is felt more particularly on the Tyne and Wear, which depend more upon shipbuilding than Teesside. The builders at Stockton and Middlesbrough seem yet to be fairly well off for orders, and their yards are kept pretty regularly employed. At Sunderland the slackness is so great that steps are being taken publicly to relieve the distress among the families of the unemployed. The prospects for shipbuilders this winter are undoubtedly very discouraging. Everything is against an improvement, and is even against the maintenance of the present position, bad as that is; materials, though they have been reduced in price, are still too expensive, wages are high, freights low, and money is scarce and far too dear. Investors cannot be persuaded to put their money into shipping property, for a good many of the steamers that are now running are bringing no profits to those who have furnished the wherewithal to build them; instead of getting any money out of their ventures, but rather are they required to supply more money to keep their property in repair. No new tonnage is wanted, for there is too much already, and freights are too low, much too low for vessels employed in certain trades. It would be much better for shipowners generally if they laid up a good proportion of steamers, for then higher rates of freight might be possible, and certainly cheaper bunker coals would be forthcoming. It is believed that very shortly there will be a large number of vessels laid up in our rivers, and the wonder is that such a course was not taken some months ago. Shipbuilders ask prices for new tonnage which cannot pay them, but nevertheless they do not tempt owners to give them orders. More especially is this so where cargo boats are concerned, and these are what are chiefly constructed at the yards on the North-East Coast. Thus it is that the builders in this district are suffering more from the slackening of trade than their competitors on the Clyde. This has a very detrimental influence on the local steel trade.

Cleveland Pig Iron.

Not for some years has there been so little buying of Cleveland pig iron as has to be reported this week, but, nevertheless, all that is produced is still going direct into consumption, and iron has to be taken out of Connal's stores as well. The outlook, however, is unfavourable, and this will continue to be the case over the winter. Makers are, therefore, going on reducing the production. During the last two months five furnaces have been blown out, and before the end of the current month another five will be put out. The output of pig iron in this district will thus have been reduced by about 8000 tons per week. This should enable the makers to maintain their prices, and, besides, it will tend to ease their cost of production, for the reduced demand for materials will bring down the prices, which all the year have been relatively dearer than those of Cleveland pig iron. By the end of the year the consumption of Durham coke will be 10,000 tons per week less than it was at the end of September, and besides this considerably less will be required for West Coast consumption, while the export demand has eased off a good deal. The reduction in the number of furnaces at work will do away with the necessity of obtaining ironstone from Northamptonshire and the Midlands.

Cleveland Iron Prices.

The quotations for Cleveland pig iron continue very unsettled, and consumers have no confidence to buy for delivery next year; it is quite impossible to say what the value of iron may be then, though the general opinion is that it will be less than it is at present. Cleveland warrants have fallen to 49s. cash, a lower price than has been known since the middle of April last year. No. 3 Cleveland G.M.B. pig iron has dropped to 49s. 6d. per ton for prompt delivery, a figure at which the makers say pig iron cannot be produced at a profit, with coke and ore at the present prices. No. 1 is at 53s. 6d. per ton; it is not so much wanted now that the shipping season is practically over, and the great difference between its value and that of No. 3 is being reduced. No. 4 foundry is at 49s. 3d.; and No. 4 forge at 49s. These are nearer No. 3 in value than usual: they are not held in second hands.

Hematite Iron.

The prospects of shipbuilding being so very unsatisfactory, the prices of East Coast hematite pig iron are weak. Mixed numbers can readily be obtained at 69s. per ton, but consumers are not prepared to give as much, and the quotation is practically a nominal one. The production lately has been considerably reduced. Rubio ore is down to 17s. 6d. per ton c.i.f. Tees, but makers hold off from giving as much, and scarcely any one is buying.

Stocks of Pig Iron.

Makers hold no stock of either Cleveland or hematite pig iron, and Connal's hold none of the latter, while of Cleveland iron they at November 30th had only 95,941 tons, which is less than they have had to report since the autumn of 1904, and it compares with 538,000 tons at the commencement of the present year, and 750,000 tons in March last year. The decrease last month was 22,577 tons. Nearly all the stock that was held at the close of last month was No. 3, for the quantity was 88,182 tons.

Pig Iron Exports.

The exports of pig iron in November from the Cleveland district—146,972 tons—were the largest ever recorded in the eleventh month of any year, and were much above the average of November over the last ten years, that was 95,700 tons, so that last month's figures were 51,000 tons, or 53½ per cent. above this. There are only half a dozen months on record when a larger shipment than 146,000 tons have had to be reported, and they are all in the present year. November last year showed the largest shipment of any month on record, but last month's figures were 1½ per cent. above the export of that month. There were reductions in the deliveries to Germany and the United States—very considerable reductions if they are compared with the quantities sent in the spring of the current year. The shipments of pig iron from the Cleveland district in the first eleven months of the present year reached 1,654,409 tons, against 1,384,528 tons in the corresponding period of last year, and 898,796 tons in 1905. It was by far the largest quantity on record—indeed, more had been sent away by sea in the first ten months of this year than in the whole twelve months of any other year. To Germany, 469,381 tons have been shipped this year, against 422,156 tons last year, and 143,466 tons in 1905. To North America, the exports reached 271,306 tons, as compared with 96,043 tons last year, and 49,716 tons in 1905. To Italy, 106,486 tons have gone; to Norway and Sweden, 84,437 tons, these figures, in both cases, being the largest on record. Scotland has taken 400,500 tons. The total deliveries oversea this year have been 1,159,025 tons, against 899,140 tons last year, and 481,864 tons in 1905.

Manufactured Iron and Steel.

Buyers are very slow, and it is only a few of the works that can be kept in regular occupation. Prices have lately been reduced, but consumers cannot afford to pay even the revised rates. Steel ship plates are at £7; steel boiler plates, £8 5s.; iron ship plates, £7; packing iron, £6 5s.; steel joists, £6 7s. 6d.; steel sheets, £8 10s.; common iron bars, £7 15s.; best iron bars, £8 2s. 6d.; best best iron bars, £8 10s.; steel hoops, £7 10s.; steel strip, £7; steel bars, £7 5s.; steel ship angles, £6 12s. 6d.; and steel engineering angles, £6 17s. 6d., all less 2½ per cent. f.o.t. Galvanised and corrugated iron or steel sheets are at £13 2s. 6d., less 4 per cent. f.o.b., 24 gauge in bundles. Heavy steel rails are at £6 5s., and cast iron chairs, £3 17s. 6d., both net f.o.b. Messrs. Bolckow, Vaughan and Co. have been able to keep their rail mills on three-quarter time this week, and their plate mills are running fully again.

Coal and Coke.

Though not so brisk as it was in the summer and early autumn, the coal trade must be described as satisfactory, and it certainly does not show anything like the evidences of depression that are noticeable in the iron and steel trades. The demand is stronger this week than last, because consumers at home and abroad are making preparations for the holidays, and are doing their best to get stocks. But there is not much buying for delivery next year; and it appears very likely that consumers will need less in 1908 than they have been taking this year, as the trade of consumers promises to be quieter than it has been. Best steam coal is at 15s. 6d. per ton, best gas coal at 14s. 3d., bunkers at 12s. 6d. to 13s., and coking coal at 12s. 9d. Coke is becoming cheaper, but is still relatively dearer than pig iron. Medium coke is at 17s. per ton, delivered at Middlesbrough furnaces, or 15s. at the collieries, and foundry coke can be got at 19s., f.o.b.

headgear ore bin, and then, after curving round an arc of a circle of 250ft. radius, runs upwards at an angle of 15 deg., raising the ore a vertical height of 47ft. and delivering it direct to the main trommel in the crusher station. This conveyor—a Robins belt 30in. wide and 278ft. long between pulley centres—handles an average of 1760 tons of ore per day, and, when running at its normal velocity of 200ft. per minute, has a carrying capacity of 280 tons per hour. It is driven at its head end by a 50 horse-power motor, which, like all the motors driving the various conveying belts on the plant, is of the slow-speed, back-geared, enclosed type. The speed of these motors is between 580 and 600 revolutions per minute, geared to give a speed to the lay shaft of 160 revolutions per minute. Each motor is fitted with a speed-controlling switch capable of regulating the speed from 25 per cent. below normal—by means of resistance inserted in series with the armature—to 25 per cent. above normal, by means of resistance inserted in series with the field magnet winding.

The main trommel, Fig. 3, 18ft. long and 5ft. in diameter, is inclined at an angle of 10 deg., and runs at 10 revolutions per minute, driven through a chain and sprocket-wheel drive and spur gearing by the 50 horse-power motor driving the conveyor carrying the ore to the crusher station. The upper half of the trommel acts as a screen and removes some 40 per cent. of the total ore brought to the crusher station, or an average of 704 tons per day, which falls as "fines" direct into the No. 1 "fines" bin; while the lower half acts as a washer, and, by removing dust and dirt from the remaining 60 per cent. of rock, facilitates its sorting on the sorting belts. The cleansed rock passes direct to two revolving screens 10ft. 6in. long, and 3ft. 6in. in diameter, inclined at 11 deg. to the horizontal and driven at 12 revolutions per minute by a 20 horse-power motor. Here it is separated into two sizes, all under 3in. cubes—some 40 per cent. of the total—passing as "intermediates" direct to the two "intermediates" sorting belts, and the remaining 60 per cent. passing direct to the two "coarse" sorting belts. On the "coarse" belts about 40 per cent. of the rock is sorted out as waste, while the remainder, falling over the head ends of the belts on to the chutes, is delivered directly to the "coarse" crushers and is broken into 3in. cubes, which drop on to grizzly bars spaced 1in. apart. About 10 per cent. of the broken rock falls between the bars into the No. 2 "fines" bin, and the remaining 90 per cent. is conveyed as "return intermediates" by the "return intermediates" belt to the "return immediates" trommel. This trommel, which is driven at 10 revolutions per minute by the 15 horse-power motor driving the "return intermediates" belt, is inclined at an angle of 10 deg., and is 4ft. long by 3ft. in diameter. It acts simply as a washer, and, after cleaning the "return intermediates" from dust and dirt, discharges them to join the "intermediates," separated by the two revolving screens previously mentioned, with which they pass direct to the "intermediates" sorting belts. There they undergo a second sorting, in which the 20 per cent. of waste still left in the "return intermediates" is picked out, bringing up the total waste rock removed from the "coarse" to 50 per cent., while at the same time an average of 50 per cent. of waste is sorted out from the "intermediates." The ore remaining on the "intermediates" belts passes direct to the "intermediates" crushers, where it is broken into 1in. cubes and is deposited in the No. 2 "fines" bin. The total waste rock sorted out averages 50 per cent. of the ore sent to the sorting belts, or 30 per cent. of the total ore mined and brought to the crusher station, and amounts on an average to about 528 tons per day.

The "coarse" and "intermediates" sorting conveyors proceed, at an inclination of 16 deg., from the chutes which catch the "coarse" and "intermediates" separated by the revolving screens, and which feed them on their respective sorting belts, up to the sorting floors situated above the waste rock bins, and pass at an angle of 10 deg. over these floors to their head ends, where they discharge the concentrated ore on to the chutes leading to the crushing plant. All four conveyors are Robins belts, 36in. wide, and each is driven at a normal speed of 50ft. per minute by a 7½ horse-power motor geared to its head pulley. The two "coarse" belts are 86ft. 6in. long between pulley centres, and each has a capacity of 58 tons per hour, while the two "intermediates" belts are 98ft. 5in. long between pulley centres, and each has a capacity of 61 tons per hour.

The "return intermediates" conveyor—a Robins belt 18in. wide and 79ft. 2in. long between pulley centres—runs upwards between the waste rock bins at an angle of 21½ deg., and extends from the grizzlies below the "coarse" crushers up to the "return intermediates" trommel. It is driven at its head end by a 15 horse-power motor at a speed of 300ft. per minute, and has a carrying capacity of 50 tons per hour. (This angle of 21½ deg. appears to the author to be the critical angle for conveyors of this type of handling rock of this size.)

The average tonnage handled per day by the various belts is as follows:—317 tons by each "coarse" belt, 382 tons by each "intermediates" belt, and 342 tons by the "return intermediates" belt; while an average of 528 tons of "fines" is deposited in the No. 2 "fines" bin, which, with the 704 tons screened out by the main trommel and deposited in the No. 1 "fines" bin, brings the average daily tonnage crushed and concentrated in the crusher station ready for conveying to the mill bins up to 1232.

The system of conveyors transporting the "fines" from the crusher station to the mill bins comprises three distinct sections; the first, consisting of a belt from the crusher station to the mill; the second of a belt running along the top of the mill; and the third of two "shuttle" belts distributing the "fines" in the mill bins. The first conveyor, a Robins belt 24in. wide and 365ft. long between pulley centres, runs under the full length of the crusher station, sloping downward at an angle of 5 deg. from below the feeder chutes of the No. 1 "fines" bin to below the feeder chutes of the No. 2 "fines" bin; and, between these two bins, passes under the conveyor feeding the waste rock from the waste rock bins of the crusher station on to the first section of the main waste conveyor to the dump. After passing below the No. 2 "fines" bin the conveyor bends rounds a curve of 250ft. radius, and on reaching the ground level is continued upwards at an angle of 18 deg., raising the "fines" a vertical height of 58ft. and feeding them direct on to the second conveyor. It is driven at its head end by a 50 horse-power motor at a speed of 350ft. per minute, and has a normal carrying capacity of 168 tons per hour. The second conveyor is a Robins belt, 20in. wide and 130ft. long between pulley centres, and runs first horizontally at right angles to the first belt for a distance of 70ft., passing through a weighing room and out above the mill bins, and then, curving round an arc of a circle of 250ft. radius, rises upwards a vertical height of 12ft. to its head end above the centre of the length of the bins. It is driven at its tail end at a speed of 286ft. per minute by the 50 horse-power motor driving the head end of the first belt, and has a normal carrying capacity of 168 tons per hour. In the weighing-room the "fines" are automatically weighed and the weight registered by means of a Blake-Denison weighing machine. The principle upon which this machine is constructed is that of weighing a fixed length of the belt at intervals of time corresponding to the travel of such length. In this case a 30ft. length of the belt is weighed at intervals of approximately 6·29 seconds. This machine and a similar one in connection with the waste-rock belt have given complete satisfaction, as the margin of error is very small indeed, not exceeding ½ to ¾ per cent. The "fines" falling over the head end of this belt drop on to a double discharge chute and are fed on to two "shuttle" belts, each of which is a Robins belt 20in. wide and half the length of the mill bins, or 84ft. long between pulley centres. These belts, which are situated one on either side of, and parallel to, the second "fines" belt, are supported by a carriage running on a double track of rails 164ft. long laid on the bin caps. As the carriage runs backwards and forwards along the track the "shuttle" belts deposit the "fines" alternately in the two end halves of the mill bins. The belts and carriage are driven by a 7½ horse-power motor, the carriage at 11·6ft. per minute, and the belts at 348ft. per minute, the direction of travel of both belts and carriage being the same, and both being reversed simultaneously at each end of the mill bins. The average tonnage handled per day by the system of "fines" belts amounts to about 1232.

(To be continued.)

THE INSTITUTION OF CIVIL ENGINEERS.

TRANMERE BAY DEVELOPMENT WORK.

At the ordinary meeting on Tuesday, 26th November, Sir William Matthews, K.C.M.G., president, in the chair, the paper read was "The Tranmere Bay Development Works," by S. H. Ellis, M. Inst. C.E. The following is an abstract of the paper:—

The works described comprise two graving docks, two floating basins, launchways, engineering shops, and other equipment of a new shipbuilding yard, together with the continuation of two town sewers. These subjects are dealt with under the following heads:—

(1) *Reclamation.*—The works are situated on what was tidal foreshore of the river Mersey, and the first step in their construction was the reclamation of the site. This was effected by a series of three dams: (*a*) A timber cofferdam, 625ft. in length, and about 36ft. in height above the foreshore; (*b*) a temporary concrete wall, 250ft. in length and 29ft. in average height; and (*c*) a clay embankment extending between low and high-water mark. The construction of the cofferdam is described in some detail, and also the measures taken to remedy a temporary breach of part of the clay dam.

(2) *Sewers.*—The form of construction of the larger of the two sewers—a culvert 6ft. 6in. in diameter, constructed by tidal work during the period of reclamation—is briefly described.

(3) *Graving docks.*—These are respectively 708ft. and 861ft. in effective length, and are largely cut out of the sandstone rock, with concrete walls above the surface of the rock (on one side only just above dock bottom), or where the rock was defective in character. The entrances are closed by floating ship caissons, which are briefly described, as are also the pumping appliances.

(4) *Basins.*—The outer floating basin, the entrances of which are closed by gates, is 15 acres in area, with a depth of water of 31ft. 7in. at high water of ordinary neap tides. The quay walls, respectively 1000ft., 850ft., and 990ft. in length (besides a frontage wall 460ft. in length), are of concrete throughout. Some account is given of the forward movement of part of the longest wall, which is founded on sand, with bearing piles driven down to rock. The inner basin, entered from the outer, is for shallow draught vessels, and is 2⅜ acres in area.

(5) *Concrete.*—The materials and methods of manipulating the concrete are briefly dealt with.

(6) *Equipment.*—The principal items of equipment are mentioned, together with some details of the power station for generating electricity by means of gas engines and dynamos.

(7) *Shop foundations.*—A description is given of the Simplex system of concrete piling, largely used on these works for the column foundations of heavy engineering shops situated on made ground.

(8) *Launchways.*—The method of forming the launchways and shipbuilding slips is described, and an account is given of the form of construction of the frontage-wall (which is founded on concrete piers sunk through 30ft. to 35ft. of silt to the rock) by grabbing from the centre of (*a*) wrought-iron caissons, (*b*) hollow concrete monoliths on an iron cutting edge.

(9) *Dredging.*—Mention is made of the methods employed in dredging about 64,000 cubic yards of rock and silt from the foreshore in front of the entrances.

The Institution of Civil Engineers: Association of Yorkshire Students.—The Parkgate Iron and Steel Company, Limited, Rotherham, has kindly consented to allow members to visit its works on the afternoon of December 20th. Members wishing to join the party are requested to communicate with one of the honorary secretaries before December 10th. The visit will be abandoned unless a sufficient number signify their intention of taking part in it.

Professorship of Engineering at Oxford.—We are informed that the sums required for starting the Professorship of Engineering at Oxford have now been raised. For initial expenses £951 have been subscribed, £500 of this coming from Merton College, and £200 from the Common University Fund, this being contingent on the remainder of the sums estimated as necessary, namely, £700 a year, and a capital sum of £800 being guaranteed from other sources before the end of the present year. A sum of £885 a year has been further guaranteed jointly from a number of sources, including New College, this being for maintenance purposes.

Physical Society Exhibition.—At the exhibition to be held by the Physical Society on Friday evening, December 13th—from 7 p.m. to 10 p.m.—at the Royal College of Science, South Kensington, the following firms will be exhibiting: Messrs. R. and J. Beck, Limited; Cambridge Scientific Instrument Company, Limited; Casella and Co., A. C. Cossor, Crompton and Co., Elliott Brothers, Everett, Edgcumbe and Co., Evershed and Vignoles, Limited; Clark, Fisher and Wadsworth, Gambrell Brothers, J. J. Griffin and Sons, A. Hilger, Limited; Leslie Miller, Nalder Brothers and Co., Nalder Brothers and Thompson, Limited; Newton and Co., R. W. Paul, James Pitkin and Co., Ross, Limited; Alexander Wright and Co., and also the Meteorological Office. From the programme, of which we have received an advance proof, there appear to be many items of considerable interest to both physicists and electrical engineers.

The Imperial College of Science and Technology.—The Earl of Crewe, chairman of the Governing Body of the Imperial College of Science and Technology, has authorised the publication of the following communication:—The Governing Body of the Imperial College of Science and Technology have appointed three standing committees, a Finance Committee (chairman, Sir Francis Mowatt), an Education Committee (chairman, Mr. Arthur Acland), and a General Purposes Committee (chairman, Lord Halsbury). In addition, they have appointed two temporary committees, a Transfer Committee (chairman, Mr. Arthur Acland), and an Organisation Committee (chairman, Mr. Gerald Balfour; vice-chairman, Sir William White). Matters relating to the transfer to the Imperial College of the constituent institutions, which it has been arranged shall take effect as from the 1st January next, and to the transfer of land from the Exhibition Commissioners, have been referred to the Transfer Committee. The Organisation Committee, to which have been referred matters relating to the future organisation of the Imperial College, have appointed four sub-committees to consider questions arising under this head in relation to the following sciences or groups of sciences, viz.:—(1) Mining and metallurgy (chairman of the sub-committee, Sir Julius Wernher); (2) other branches of engineering (chairman, Sir John Wolfe Barry); (3) biological sciences (chairman, Sir Archibald Geikie); and (4) other pure and applied sciences (chairman, Sir Arthur Rücker). The Governing Body have authorised the appointment of persons not members of the Governing Body who are specially conversant with the sciences in question, or with their industrial applications, as additional members of these sub-committees, which are now engaged in considering the questions referred to them. The Governing Body have also approved in principle the appointment of a principal officer of the Imperial College, and have referred the question of his title and functions to the Organisation Committee.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Decline in Pig Iron Prices.

Crude iron quotations have been in several instances materially reduced in order to bring out further business, this course being taken by producers, who are coming to the end of their present contracts, and who are anxious about the early future. Some sellers are understood to be willing to accept reductions of as much as 3s. or 4s. upon recent rates. Quite a general figure for Northampton iron is now 53s., and, indeed, 50s. is talked of, a level which has not been heard of for some two years past. Derbyshire forge iron is quoted 54s. and 55s., and some descriptions of Staffordshire are 53s. to 53s. 6d. Purchasers are buying only from hand to mouth, and stocks both in their own and in makers' hands are practically non-existent. There seems some uncertainty as to the outlook, among the possibilities being a recurrence of American dumping in the spring.

Manufactured Iron.

Marked bars are quoted £9, with the Earl of Dudley's brand £9 12s. 6d., the second grade of the "list" houses being £8. A fairly good demand is experienced for unmarked bars at £7 2s. 6d. to £7 7s. 6d., and North Staffordshire sorts are £7 10s. Plain sheet makers find business quiet, and quote singles £8 to £8 5s.; doubles, £8 2s. 6d. to £8 7s. 6d.; and trebles, £8 15s. to £9. Galvanised corrugated sheets of 24 gauge f.o.b. Liverpool are £13 2s. 6d., with a good foreign demand from South America, India, and Australia. Spelter is in only small inquiry, hard qualities being quoted £17 12s. 6d. at stations in the Birmingham district. Rivet iron is quoted £7 15s.; slit nail rods, £8 10s.; gas strip, £7 10s. to £7 12s. 6d.; and hoop iron, £8 5s.

A Moderate Demand for Steel.

There is a limited inquiry for semi-finished steel, with Bessemer billets quoted £5 7s. 6d., and Siemens £5 10s. German competition is being increasingly felt. With regard to sections, an improvement in the carriage and wagon building industries is occasioning an improved demand for angles, channels, and plates, and quotations are sustained at: Angles, £6 15s.; girder plates, £7 5s. to £7 15s.; mild bars, £7 10s. to £7 15s.; and boiler plates, £8 12s. 6d. to £8 15s.

Mines Drainage Commissioners.

With regard to the progress of operations in connection with the South Staffordshire Mines' Drainage Commissioners, Mr. E. B. Marten reports with reference to the surface works that in the Tipton district the Moxley stream has been raised where swagged. Great efforts have been made to prevent acid water from coming into the watercourses, and thence into the canals. In the Kingswinford district a long-promised and good permanent work has been effected by making a direct channel into the canal jointly with others, which provides a safe outlet for water pumped by the Stourbridge Glazed Brick and Fireclay Company's engine. In the Old Hill district another long-promised work is being done in diverting the water from the locality of the old Gad's Green reservoir into the canal at Bumble Hole. Mr. Edmund Howl, engineer to the Tipton district, reports as to that district that the rainfall during the four weeks has been 2·44in. The pumping and tanking has been 9,132,000 gallons per twenty-four hours, compared with 9,138,000 gallons the previous month, and 9,030,000 gallons in the corresponding period of last year.

Wolverhampton Tramways.

The Wolverhampton Town Council have approved the clauses relating to tramways in the draft of a bill which it is proposed to promote in the next session of Parliament, mainly to secure an extension of time for tramway construction, including the completion of the Led-road route.

Birmingham Tramways.

Mr. Alfred Baker, the general manager of the Birmingham Corporation Tramways, has delivered an address before the Birmingham and Midland Institute Scientific Society strongly advocating the overhead tramway system as compared with the conduit system, chiefly on the ground of economy. The London County Council Tramways, on the conduit system, after providing for interest and sinking fund, left a net balance of less than £10,000 on a turnover of nearly a million and a-half sterling. In Birmingham, on the overhead system, where the traffic could not, of course, compare at all with London, it was expected that the profits would far exceed that amount on about one-sixth of the London capital expenditure. In his opinion, the overhead system was by far the best in every respect, except perhaps from the æsthetic point of view. Of the three chief methods of overhead construction, the span wire system, adopted by Birmingham, was, he considered, far superior to the other methods. It was certainly neater, and it gave steadier running. He announced that new brakes were under test.

Electric Supply Improvements.

The Birmingham City Council on Tuesday passed a resolution authorising their Electric Supply Committee to provide additional electric plant at an estimated cost of £231,285, and instructing the Finance Committee to borrow that amount. The Electric Supply Committee showed that in 1908 they would have to deal with a maximum demand of 11,660 kilowatts, while the capacity of their plant—after changes now recommended at Dale End—would be 14,740 kilowatts. The Committee have, however, made a forecast of their requirements for the next three or four years. It is proposed to discontinue Dale End as a generating station owing to the greater economy which can be effected in the distribution of boiler power, with the greater room at Summer-lane. The generating cost at Summer-lane is only 0·284d., as compared with 1·5d. at Dale End. Dale End will be available as a sub-station for storing and distributing power, and will provide accommodation for motors on hire testing purposes, and extra offices. The margin of capacity at Summer-lane under this arrangement is as small as is consistent with safety, and leaves no margin for progressive development. It is such development that the Committee have now to consider, and they assure the Council that although a comprehensive schedule of new plant is presented, it will only be erected in accordance with the Committee's experience of the increased demand which is anticipated. The amount expected to be required for next year is £99,000, when some of it—£60,000 or £70,000—will probably be wanted about November or December, leaving the remainder for 1909. The expenditure up to the present time has, the Committee intimate, been remunerative and is expected to continue so.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

Manchester, Wednesday.

Pig Iron Market Disorganised.

It is difficult to write with certainty as to the condition of the pig iron market during the past week. The Lincolnshire Association took what is thought here to be the extraordinary, as well as unnecessary, course of reducing No. 3 foundry 6d. per ton. Why this should have been done when merchants were freely quoting 2s. per ton under the official price it is difficult to say. It has been practically of no use to the trade. Hematite iron was

thought to have touched "bottom," but as compared with last week, it is fully 1s. 6d. per ton lower, and the prospects are far from bright. Derbyshire is most variable of all, and reports on Tuesday's Iron 'Change indicated a serious drop. Even makers' representatives were bound to admit that trade was very dull, and for delivery early in the year fair concessions would be made for quantity. Staffordshire was also a shilling or so lower; but Middlesbrough open brands, notwithstanding the erratic course of warrants, were steadier than might have been expected under the circumstances. No doubt the heavy shipments have something to do with this, but so far as this centre is concerned, buyers are still holding off except for pressing requirements. Forge iron is in poor request.

Finished Iron.

One prominent merchant informed us that business in this department had fallen flat indeed, and was almost the weakest point in the market. Orders of any weight were very scarce.

Steel.

Several makers reported a fair business in some sorts of structural and similar work, but foreign billets were offering at low prices. The principal makers in Lancashire are, however, placing their output at fair rates.

Copper.

There was little or no change to note in manufactured stuff.

Quotations.

Pig iron: Lincolnshire No. 3 foundry, 59s. 6d.; Staffordshire, 57s. 6d.; Derbyshire, 58s. 6d.; Middlesbrough, open brands, 57s. 6d. Scotch: Gartsherrie, 67s. 9d.; Glengarnock, 68s.; Eglinton, 64s. 9d.; Dalmellington, 64s. 3d., delivered Manchester. West Coast hematite, 67s. 6d.; East Coast ditto, 69s., both f.o.t. Scotch, delivered Heysham: Gartsherrie, 65s. 6d.; Glengarnock, 65s. 9d.; Eglinton, 62s. 6d.; Dalmellington, 62s. Delivered Preston: Gartsherrie, 66s. 9d.; Glengarnock, 67s; Eglinton, 63s. 6d.; Dalmellington, 63s. 3d. Finished iron: Bars, £7 10s.; hoops, £8 2s. 6d.; sheets, £8 5s. Steel: Bars, £7 5s. to £7 15s.; hoops, £8 2s. 6d.; sheets, £8 15s.; boiler plates, £8 12s. 6d.; plates for tank, girder, and bridge work, £7; English billets, £5 5s. to £5 10s.; foreign ditto, £4 15s. to £4 17s. 6d. Copper: Sheets, £80; tough ingot, £68 to £69; best selected, £65 per ton; copper tubes, 10½d.; brass tubes, 8½d.; condenser, 9½d.; rolled brass, 7½d.; brass wire, 7½d.; brass turning rods, 7d.; yellow metal, 7¼d. per lb. Sheet lead easier at £20 15s. per ton. English tin ingots lower, being now £135 per ton.

The Lancashire Coal Trade.

There was a good attendance on the Coal Exchange, but merchants were not inclined to operate to any great extent. Still, the feeling in shipping was reported slightly better. House coal was quiet, but slack remains firm, and in good consumptive request.

BARROW-IN-FURNESS, Thursday.

Hematites.

The business being done in the hematite iron trade is very quiet. Makers are not able to do much trade either in prompt or forward deliveries, although transactions in both classes are being made on a modest scale. The needs of the market are indeed few, and the prospects of improvement are somewhat remote. There has been a falling off in the demand from all sources, and this has been most marked in the smaller requirements of local and other makers of steel, who usually require a large delivery of hematite iron when they are doing a good business. Quotations are somewhat weaker. Mixed Bessemer numbers are at 69s. per ton net f.o.b. nominally, and warrant iron settlement price is 67s., while deliveries in three months are at 66s. 6d. net cash. On a rising market prices are always higher for forward deliveries, and on a falling market the opposite. This is proof that those who know the trade best are apprehensive of a still quieter state of things. Orders are not well held by makers, and the production of iron is very low, yet stocks do not increase. Warrant stocks now stand at 6482 tons, the same as last week, and makers' stocks are very slight. A smaller business is being done in special hematites and in spiegeleisen and ferro-manganese. Iron ore is in limited demand, and good ordinary native sorts are selling at 14s. net at mines.

Steel.

There is no improvement to note in the steel trade. The demand for railway material, which is the chief production of the district, is very small, and there are very few specifications in the market of any size, although prices have come down somewhat, heavy rails being at £6 6s. per ton net f.o.b. There are prospects of better times in shipbuilding material, but at present makers have very few orders in hand. Merchant steel is very quiet, and there is not much business being done in heavy foundry steel for shipbuilding and engineering purposes.

Shipbuilding and Engineering.

No new orders have been secured for new shipping tonnage, but prospects are brighter than they have been; but when competition is so keen it is difficult to estimate where the few orders in the market are likely to be placed. Engineers are also expecting some new orders, and in the meantime are very busy.

Shipping and Coal.

The shipping trade remains inactive. The exports of iron last week amounted to 4181 tons, and of steel to 5575 tons, a total of 9756 tons, against 11,499 tons in the corresponding week of last year, a decrease of 1743 tons. The shipments of the year to date have reached 785,357 tons, as against 757,209 tons for the corresponding period of last year, an increase of 28,148 tons. Freights are lower. Coal and coke are declining in prices gradually week by week, as the demand falls away.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Business Position.

THE situation in this district has not materially changed, except that there is a further reduction in the prices of Lincolnshire irons locally used, as well as in Derbyshire foundry and forge. In the heavy industries generally fresh orders would be very welcome, in marine and military material especially. The manufacturers of railway rolling stock continue to be most satisfactorily employed, and steady business is reported, the work in hand being largely for foreign and colonial markets, and the home companies have also been affording more employment for makers of railway material. It is expected that their requirements will get considerably heavier later on. The coal trade remains firm, the prolonged export business being an important factor in the situation.

House Coal.

The weather continues very variable, and expectations of any general reduction in household fuel have not been, or are likely to be, realised. Christmas is too near, with its accustomed holidays, to admit of easier quotations being established. A fairly brisk business is being done both on local and distant account. Coalowners recognise no call to revise lists at this advanced season of the year. Best Barnsley is quoted at 13s. 6d. to 14s. 6d. per ton; secondary qualities, from 12s. to 12s. 6d. per ton.

Steam Coal Still Active.

The export business is well maintained, both with Hull and Grimsby. Although the figures of exports from both ports are again considerably higher than for the corresponding period of last year, the trade cannot be continued much longer on this level, and the shrinkage of business with the upper Baltic ports is getting more evident. Considering the advanced season, however, the foreign requirements are exceedingly well maintained. From Hull, for the week ending 26th November, the total exports were 80,596 tons, compared with 54,686 tons for the similar week of last year. The Swedish port of Oxelösund received the heaviest weight, 11,989 tons, Buenos Ayres coming next with 4302 tons. From Grimsby, for the week ended November 29th, the exports to foreign destinations amounted to 34,810 tons, against 28,197 tons for the corresponding week of last year. Geffe was first with 7532 tons, and Hamburg next with 5578 tons. During the same week the coastwise trade from Grimsby fell to 1031 tons, from 2026 tons for the similar period of last year. There is nothing fresh to report in regard to the trawling and supplementary railway contracts, which fall out at the end of the year. Values are firmly maintained, Yorkshire hards making, in the open market, from 12s. 6d. to 13s. per ton at the pit.

Coke, Coking, Slack, and Manufacturing Fuel.

Coke is again somewhat weaker, best washed being this week quoted at 13s. to 14s. per ton, and unwashed 12s. to 13s. per ton. These figures show a reduction of 6d. per ton on those given in last report. The weakening is through the lessened call for small coal for the Lancashire and Yorkshire textile districts, thus temporarily increasing the output of coke beyond the market requirements. The best qualities of slacks for steam-producing purposes are at former figures—6s. 6d. to 7s. per ton.

Hematites.

Affairs remain pretty much as previously reported, and quotations are unaltered; for delivery at Sheffield and Rotherham, West Coast remains at 86s. 6d. to 88s. 6d. per ton; and East Coast at 82s. 6d. to 84s. 6d. per ton, East Coast subject to 2½ per cent.

Another Reduction in Lincolnshire Irons.

At their meeting, last Friday, the Lincolnshire Ironmasters' Association reduced their quotations for the iron largely used in this district to the following prices:—No. 3 foundry, 55s. 6d. per ton; No. 4 foundry, 55s. per ton; No. 4 forge, 54s. 6d. per ton; No. 5, mottled, white, and basic, 55s. 6d. per ton. These figures, as compared with those given last week, exhibit a drop of 6d. per ton in No. 3 foundry, of 1s. per ton in No. 4 foundry, of 1s. 6d. in No. 4 forge, and of 2s. 6d. per ton in No. 5 mottled, white, and basic. The reduction has, no doubt, been made with the object of inducing purchasers to come into the market and buy in quantities for next year. What is now being bought is for immediate delivery. The position is somewhat peculiar, for with pig iron very scarce prices are being reduced. More business, though in no great quantities, has been done, but it has been to meet current requirements.

Derbyshire Irons, &c.

Another reduction of 1s. a ton is reported in Derbyshire No. 3 foundry and No. 4 forge, which are now quoted at 58s. and 56s. per ton respectively. While there is considerable pressure for early deliveries, we hear of additional business being done for forward account. Bars remain at the lower rate given last week, £7 10s. to £8 per ton; sheets, £10 10s. per ton; Bessemer billets, £8 5s. per ton; Siemens billets, £8 15s. per ton.

Steel.

The reports respecting the steel trade generally are not so gratifying as during the earlier months of the year. There has been much less done with the United States in special steels, including high-speed tool steels, and the demand from several other markets has not quite equalled expectations. In the lighter steel trades the department most actively employed is the manufacture of files, and there are excellent prospects of the good business being maintained. A fair trade is reported in engineering tools generally, although there is not probably so active a request as was the case some months ago. Tenders for the supply of tools for the royal dockyards will, it is expected, be invited shortly.

Railway Work.

This department continues to be steadily employed, with every prospect of the works engaged in it being kept busy for a considerable time. The orders are chiefly for India, Australia, and South America, and the outlook in all these markets is most encouraging. More work is being placed by home companies, though not to the extent that was anticipated when the labour troubles terminated.

The Christmas Trade.

Some disappointment is expressed with regard to the lighter staple industries. The season business in cutlery, silver, and plated goods, to meet the special requirements of Christmas and the New Year, opened out very hopefully, but in several quarters it is reported that the early promise has not been maintained. It is difficult to get at the actual condition of affairs, as reports differ very materially. Some of the establishments have been satisfactorily engaged in most departments, and a good deal more money has been paid in wages than was the case last year. In other directions less gratifying reports are given; but it is to be hoped, when the work of the twelvemonth comes to a close, that the results will not prove so disappointing as some people appear to anticipate.

NORTH OF ENGLAND.

(From our own Correspondent.)

Shipbuilding.

THE shipbuilding industry is feeling the falling off in trade more intensely than any other branch of business carried on on this North-East Coast; the depression in it becomes more pronounced every week, and is felt more particularly on the Tyne and Wear, which depend more upon shipbuilding than Teesside. The builders at Stockton and Middlesbrough seem yet to be fairly well off for orders, and their yards are kept pretty regularly employed. At Sunderland the slackness is so great that steps are being taken publicly to relieve the distress among the families of the unemployed. The prospects for shipbuilders this winter are undoubtedly very discouraging. Everything is against an improvement, and is even against the maintenance of the present position, bad as that is; materials, though they have been reduced in price, are still too expensive, wages are high, freights low, and money is scarce and far too dear. Investors cannot be persuaded to put their money into shipping property, for a good many of the steamers that are now running are bringing no profits to those who have furnished the wherewithal to build them; instead of getting any money out of their ventures, but rather are they required to supply more money to keep their property in repair. No new tonnage is wanted, for there is too much already, and freights are too low, much too low for vessels employed in certain trades. It would be much better for shipowners generally if they laid up a good proportion of steamers, for then higher rates of freight might be possible, and certainly cheaper bunker coals would be forthcoming. It is believed that very shortly there will be a large number of vessels laid up in our rivers, and the wonder is that such a course was not taken some months ago. Shipbuilders ask prices for new tonnage which cannot pay them, but nevertheless they do not tempt owners to give them orders. More especially is this so where cargo boats are concerned, and these are what are chiefly constructed at the yards on the North-East Coast. Thus it is that the builders in this district are suffering more from the slackening of trade than their competitors on the Clyde. This has a very detrimental influence on the local steel trade.

Cleveland Pig Iron.

Not for some years has there been so little buying of Cleveland pig iron as has to be reported this week, but, nevertheless, all that is produced is still going direct into consumption, and iron has to be taken out of Connal's stores as well. The outlook, however, is unfavourable, and this will continue to be the case over the winter. Makers are, therefore, going on reducing the production. During the last two months five furnaces have been blown out, and before the end of the current month another five will be put out. The output of pig iron in this district will thus have been reduced by about 8000 tons per week. This should enable the makers to maintain their prices, and, besides, it will tend to ease their cost of production, for the reduced demand for materials will bring down the prices, which all the year have been relatively dearer than those of Cleveland pig iron. By the end of the year the consumption of Durham coke will be 10,000 tons per week less than it was at the end of September, and besides this considerably less will be required for West Coast consumption, while the export demand has eased off a good deal. The reduction in the number of furnaces at work will do away with the necessity of obtaining ironstone from Northamptonshire and the Midlands.

Cleveland Iron Prices.

The quotations for Cleveland pig iron continue very unsettled, and consumers have no confidence to buy for delivery next year; it is quite impossible to say what the value of iron may be then, though the general opinion is that it will be less than it is at present. Cleveland warrants have fallen to 49s. cash, a lower price than has been known since the middle of April last year. No. 3 Cleveland G.M.B. pig iron has dropped to 49s. 6d. per ton for prompt delivery, a figure at which the makers say pig iron cannot be produced at a profit, with coke and ore at the present prices. No. 1 is at 53s. 6d. per ton; it is not so much wanted now that the shipping season is practically over, and the great difference between its value and that of No. 3 is being reduced. No. 4 foundry is at 49s. 3d.; and No. 4 forge at 49s. These are nearer No. 3 in value than usual: they are not held in second hands.

Hematite Iron.

The prospects of shipbuilding being so very unsatisfactory, the prices of East Coast hematite pig iron are weak. Mixed numbers can readily be obtained at 69s. per ton, but consumers are not prepared to give as much, and the quotation is practically a nominal one. The production lately has been considerably reduced. Rubio ore is down to 17s. 6d. per ton c.i.f. Tees, but makers hold off from giving as much, and scarcely any one is buying.

Stocks of Pig Iron.

Makers hold no stock of either Cleveland or hematite pig iron, and Connal's hold none of the latter, while of Cleveland iron they at November 30th had only 95,941 tons, which is less than they have had to report since the autumn of 1904, and it compares with 538,000 tons at the commencement of the present year, and 750,000 tons in March last year. The decrease last month was 22,577 tons. Nearly all the stock that was held at the close of last month was No. 3, for the quantity was 88,182 tons.

Pig Iron Exports.

The exports of pig iron in November from the Cleveland district—146,972 tons—were the largest ever recorded in the eleventh month of any year, and were much above the average of November over the last ten years, that was 95,700 tons, so that last month's figures were 51,000 tons, or 53½ per cent. above this. There are only half a dozen months on record when a larger shipment than 146,000 tons have had to be reported, and they are all in the present year. November last year showed the largest shipment of any month on record, but last month's figures were 1½ per cent. above the export of that month. There were reductions in the deliveries to Germany and the United States—very considerable reductions if they are compared with the quantities sent in the spring of the current year. The shipments of pig iron from the Cleveland district in the first eleven months of the present year reached 1,654,409 tons, against 1,384,528 tons in the corresponding period of last year, and 898,796 tons in 1905. It was by far the largest quantity on record—indeed, more had been sent away by sea in the first ten months of this year than in the whole twelve months of any other year. To Germany, 469,381 tons have been shipped this year, against 422,156 tons last year, and 143,466 tons in 1905. To North America, the exports reached 271,306 tons, as compared with 96,043 tons last year, and 49,716 tons in 1905. To Italy, 106,486 tons have gone; to Norway and Sweden, 84,437 tons, these figures, in both cases, being the largest on record. Scotland has taken 400,500 tons. The total deliveries overseas this year have been 1,159,025 tons, against 893,140 tons last year, and 481,864 tons in 1905.

Manufactured Iron and Steel.

Buyers are very slow, and it is only a few of the works that can be kept in regular occupation. Prices have lately been reduced, but consumers cannot afford to pay even the revised rates. Steel ship plates are at £7; steel boiler plates, £8 5s.; iron ship plates, £7; packing iron, £6 5s.; steel joists, £6 7s. 6d.; steel sheets, £8 10s.; common iron bars, £7 15s.; best iron bars, £8 2s. 6d.; best best iron bars, £8 10s.; steel hoops, £7 10s.; steel strip, £7; steel bars, £7 5s.; steel ship angles, £6 12s. 6d.; and steel engineering angles, £6 17s. 6d., all less 2½ per cent. f.o.t. Galvanised and corrugated iron or steel sheets are at £13 2s. 6d., less 4 per cent. f.o.b., 24 gauge in bundles. Heavy steel rails are at £6 5s., and cast iron chairs, £3 17s. 6d., both net f.o.b. Messrs. Bolckow, Vaughan and Co. have been able to keep their rail mills on three-quarter time this week, and their plate mills are running fully again.

Coal and Coke.

Though not so brisk as it was in the summer and early autumn, the coal trade must be described as satisfactory, and it certainly does not show anything like the evidences of depression that are noticeable in the iron and steel trades. The demand is stronger this week than last, because consumers at home and abroad are making preparations for the holidays, and are doing their best to get stocks. But there is not much buying for delivery next year; and it appears very likely that consumers will need less in 1908 than they have been taking this year, as the trade of consumers promises to be quieter than it has been. Best steam coal is at 15s. 6d. per ton, best gas coal at 14s. 3d., bunkers at 12s. 6d. to 13s., and coking coal at 12s. 9d. Coke is becoming cheaper, but is still relatively dearer than pig iron. Medium coke is at 17s. per ton, delivered at Middlesbrough furnaces, or 15s. at the collieries, and foundry coke can be got at 19s., f.o.b.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General State of Business.

THERE appears to be less anxiety in commercial circles in prospect of the passing away of the financial crisis, and the anticipation of a reduction in the present high price of money. Still, it is to be feared that manufacturing industry and trade enterprise generally have sustained a check from which it will take them some time to recover. Not merely is fresh work more difficult to obtain in connection with our staple industries, but foreign competition is becoming more aggressive and difficult to cope with owing to the low prices quoted for imported goods. Wages and the cost of materials will require, it is believed, considerable modification before the iron and steel manufacturers are in a position to attract much new business.

The Warrant Market.

The Glasgow warrant market has since last report been dull and irregular, the business consisting mainly of transactions between dealers of a speculative character, with little or no indication of demand on the part of consumers or the outside public. Cleveland warrants have sold from 49s. 3d. to 49s. 9d., receding to 49s. cash, at 49s. 3d. to 49s. one month, and at 48s. 6d. to 48s. 10½d. and back to 48s. 7d. for delivery in one month. There has been scarcely any inquiry for Cumberland hematite warrants, which are nominally about 9d. per ton lower.

Scotch Makers' Pig Iron.

There has been a steady output of Scotch makers' pig iron, and the furnaces in blast number 85, compared with 90 at this time last year. The stock of pig iron in the Glasgow warrant stores amounts to only 1200 tons, with warrants in circulation for 1000 tons. While the possibilities of speculation in Scotch warrants are thus much restricted, there is a good business doing in pig iron direct with the merchants and makers, the bulk of the trade being understood to consist of deliveries under contracts arranged some time ago. Current demand is mainly for No. 3 pig iron, and is reported to consist generally of small quantities for prompt delivery. As compared with warrants, prices of makers special brands are well maintained. Monkland, No. 1, is quoted at Glasgow, 64s.; No. 3, 61s.; Carnbroe, No. 1, 65s. 6d.; No. 3, 61s. 6d.; Clyde, No. 1, 68s.; No. 3, 63s.; Gartsherrie, No. 1, 68s. 6d.; No. 3, 63s. 6d.; Calder, No. 1, 69s. 6d.; No. 3, 64s.; Summerlee, No. 1, 71s. 6d.; No. 3, 63s.; Langloan, No. 1, 75s.; No. 3, 70s.; Coltness, No. 1, 90s.; No. 3, 70s.; Glengarnock, at Ardrossan, No. 1, 71s.; No. 3, 65s.; Eglinton, at Ardrossan or Troon, No. 1, 63s.; No. 3, 60s. 6d.; Dalmellington, at Ayr, No. 1, 65s. 6d.; No. 3, 60s. 6d.; Shotts, at Leith, No. 1, 70s.; No. 3, 65s.; Carron, at Grangemouth, No. 1, 73s.; No. 3, 65s. Scotch hematite is quoted 72s. 6d. to 73s. 6d. per ton for delivery at the West of Scotland steel works.

Pig Iron Shipments and Imports.

The shipments of pig iron from Scottish ports in the past week amounted to 9265 tons, against 9494 in the corresponding week of 1906. To the United States 125 tons were despatched, Canada 160, South America 125, India 15, Australia 203, France 70, Italy 340, Germany 1645, Holland 275, Belgium 10, other countries 1363, the coastwise shipments being 4944 tons, compared with 2436 in the corresponding week of last year. The arrivals of Cleveland pig iron at Grangemouth have been 11,462 tons, being 2806 tons more than in the corresponding week, while there is a total increase in these imports since the beginning of the year amounting to 16,606 tons.

Finished Iron and Steel.

Business has been quiet in the finished iron and steel departments. It does not appear that the recent reduction of malleable iron prices has had much effect in attracting new orders, and some makers who were lately well employed now complain that it is becoming difficult to keep their works going full time. It is alleged that Belgian common bars are being offered for delivery at Scottish ports at about £1 10s. below the selling price of makers here; but it is difficult to ascertain whether business is likely to result upon such terms. Makers of steel are encountering similar difficulties, and it is said they are being underquoted, not merely by continental, but by English sellers. All this would seem to show that prices must come down still further, and, if so, the steel manufacturer must have relief in lower wages and cheaper costs of raw material and fuel.

The Shipbuilding Trade.

Want of employment is increasing in this important industry. One of the Greenock shipyards has been closed, the last vessel having been launched there a few days ago, and there being no more orders on hand. The dock and engineering works of the same company are being run on short time. On the upper reaches of the Clyde there is a great lack of employment, and fresh work is urgently necessary. The new shipping launched on the Clyde during the past month amounted to 31,791 tons, against 41,016 tons in the same month of last year, and 55,358 tons in November, 1905. It is estimated that only about 12,000 tons of new shipping was booked during the past month on the Clyde, the total for the whole of the Scottish shipyards being about 14,000 tons.

Torpedo Factory for the Clyde.

Sir Hugh Shaw Stewart, of Ardgowan, has received notice from the Admiralty that they intend immediately to exercise their powers compulsorily to purchase about 10 acres of ground at Fort Matilda, Greenock, on which to erect works for the manufacture of torpedoes. Instructions have been given for clearing the ground in order that building operations may be commenced without delay. The site of the new factory is within easy access of the torpedo testing range which the Government is about to lay down in Loch Long.

The Coal Trade.

There was a very marked falling off in the coal shipments in the past week, the decrease at the whole of the Scottish ports amounting to no less than 56,800 tons, compared with the quantity despatched in the preceding week. Business in house coal for home consumption has, at the same time, been exceptionally active in consequence of wintry weather. Prices of coal are for the most part without material alteration.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Welsh Coal Trade.

IN journeying over a wide area of the coal district last week I was impressed with the great output that has taken, and is taking place, but there was a perceptible lessening of stocks at some of the "bays," showing that clearances continue large. From Cardiff there was a large despatch last week, but a falling off was indicated at Swansea, principally on account of the stormy weather. Newport figures better, and accounted for over 86,000 tons, 71,875 tons going foreign, and 14,175 coastwise. In the Monmouthshire district the railway arrangements to meet the needs of still larger output are progressing well, and the wide extent of colliery development is full of activity.

Latest Coal Prices.

Prices may be regarded as firm with upward signs, but much about the same, remaining in the 19s. rut. Latest quotations on 'Change, Cardiff, were:—Best steam, 19s. to 19s. 6d.; 19s. 3d. was a common figure; seconds, 18s. 6d. to 18s. 9d.; ordinary large steam, 17s. 6d. to 18s.; drys, best, 19s. to 19s. 6d., scarce; ordinary, 17s. 9d. to 18s. 6d.; best Monmouthshire, black vein, 17s. 9d. to 18s.; Western Valley, 17s. 3d. to 17s. 6d.; Eastern Valley, 16s. 3d. to 16s. 9d.; best house coal, in strong demand, 19s. 6d. to 20s. 6d.; seconds, 17s. 6d. to 18s.; No. 3 Rhondda, 19s. 6d. to 20s.; through, 16s. 6d. to 17s.; No. 3 smalls, 12s. 6d. to 13s. 6d.; No. 2 Rhondda, slightly easier, 15s. to 15s. 6d.; through, 11s. 6d. to 12s.; No. 2 smalls, 9s. 6d. to 9s. 9d.; best washed nuts, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d.; peas, 13s. to 13s. 6d.; seconds, 12s. 9d. to 13s.; best smalls, 11s. to 11s. 6d. The large output is telling on price of small, which is weakening; second small steam, 10s. to 10s. 6d.; other smalls, including dry, 8s. 6d. to 9s. 6d.; patent fuel, 18s. to 18s. 6d.; coke, furnace, 19s. to 20s.; foundry, 21s. to 27s. Higher coal prices are likely.

Pitwood.

Prices remain firm, and stocks have been low, though this week a large number of cargoes have come in, some from Russia. Latest prices range from 24s. to 24s. 6d., ex-ship.

Anthracite.

Without having much animation there is still a tolerable trade being done, and more activity would be shown but for the stormy weather. This week, at Swansea, there was little alteration in price: best hand picked samples remaining from 29s. to 30s.; and seconds, 27s. to 28s. 6d. Other quotations were: Swansea Valley, big vein, 26s. to 27s. 6d.; red vein, 20s. to 20s. 6d.; machine made cobbles, 27s. 6d. to 28s.; nuts, 28s. to 29s. 6d.; peas, 14s. to 16s.; rubbly culm, 8s. 6d. to 8s. 9d.; duff, 4s. 9d. to 5s. Other Swansea quotations are:—Steam, best large, 18s. 6d. to 20s.; seconds, 16s. 9d. to 17s. 6d.; ordinary large bunker, 14s. 6d. to 15s.; through bunker, 12s. 6d. to 12s. 9d.; small, 8s. 6d. to 10s. No. 3 Rhondda, 20s. to 20s. 3d.; small, 13s. 3d. to 13s. 9d. Patent fuel, 17s. 3d. to 17s. 9d.

Iron and Steel.

Following the coming of a large number of ironworkers from America, I now note that one of the long-expected consignments of steel has been made to Wales. This took the form this week of 3400 tons steel billets, consigned from New York to Jones, Heard and Co., Newport. On the same day 306 tons of pig iron came to the same port from Ayr, and this week a large cargo of steel bars from Rotterdam and one from Antwerp. In iron ore, large shipments to Welsh ports continue, one fine cargo of 3000 tons being received by Ebbw Vale from Bilbao. Baldwin's, Swansea, is importing from Caen. A number of cargoes of scrap iron have come from Falmouth, principally to Swansea, and one cargo to Newport from Southampton. From Cardiff, one large cargo of steel rails and spikes was sent to Calcutta, and 300 tons iron to Huelva. From Newport, 600 tons rails went to Devonport. There is not much animation in the trade, but the large works are moderately occupied. Some grades of pig were quoted lower on 'Change, Swansea: Bessemer, mixed numbers, 67s., instead of 67s. 9d. Middlesbrough, 49s., same as last week; Scotch also the same, 59s. 6d; and Welsh hematite, 72s. 6d.. Siemens steel bars are at £5 5s.; Bessemer, £5 2s. 6d. Steel rails, heavy, are not quoted, but I note that North of England quotes as low as £6 5s., which may account for the price remaining open to negotiations. Iron ore at Newport was at 15s. 9d. to 16s. 3d. for Rubio; 15s. 6d. to 15s. 9d. for Almeria. These figures indicate a droop.

Tin-plate.

Business continues much about the same. In the Swansea district the make was affected by the repairs going on at two leading mills, and the total was limited to 71,250 boxes. The shipments, too, were restricted, and only amounted to 52,372 boxes, leaving stocks at 149,749 boxes. At Llanelly there is a satisfactory demand for tin-plates, and prices are firmer. The works are now well supplied with orders, and the winter trade is tolerably well assured. The proposed combination in the trade is progressing, and there now seems a hopeful prospect by which the mutual interests of tin-plate and steel works will be safeguarded. The associated industries of the Swansea Valley are flourishing. Copper refineries are brisk, and spelter doing good work; nickel factories brisk. In the matter of weldless tubes there has been a good shipment of late to South America and other destinations from Landore. The latest statement on 'Change, Swansea, is that the tin-plate market is active, and a good deal of business is being done for early delivery. Official quotations are:—Ordinary tin-plate, Bessemer and Siemens, I.C. 20 × 14 × 112 sheets, 13s.; I.C. ternes, 28 × 20, 112 sheets, 24s. 6d.; C.A. roofing sheets, £10. Big sheets for galvanising, £10. Finished black plates, £10 to £10 5s. Galvanised sheets, 24 g., £13 2s. 6d. Other Swansea quotations are:—Block tin, £133 5s.; copper, £61 10s.; lead, £16; spelter, £21 5s.; silver 26⅝d. per oz.

The Small Coal Question.

This long existing difficulty is again to be brought forward. At a meeting held in Aberdare lately it was arranged that this, and the question of sub-contracting, should again be brought under discussion.

The Coal Traffic at Cardiff.

As showing the pressure now being brought to bear on the port and dock officials I note that one day this week 31 large vessels were cleared with a total of 52,000 tons, several of them over 5000 tons cargo; and, in addition, there was a number of smaller, but important ones.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, November 28th.

THE American steel industry is in a pretty serious condition over the declining tendency in prices, in the curtailment of orders and the countermanding of orders. Manufacturers are at a loss as to the best course to pursue under the present circumstances, and as yet have no fixed policy. An influential meeting of steel manufacturers was held in this city a few days ago with a view of gathering together the scattered forces and adopting some line of policy to tide over the present disturbed conditions. A curtailment of output is in progress in all lines of crude and finished material. The greatest curtailment is taking place in pig iron, and the output has been reduced about one-third since October 1st, and when the furnaces that will be blown out within the next few weeks are added to the present idle number, the production of iron will be probably reduced 40 per cent. below the maximum. Business in steel rails is practically dead excepting for exports. Quite a number of export orders are being figured upon, and every effort will, of course, be made to secure them. Some rail mills are reducing their production this week. Extensive repairs will be made in these mills, so that there will be practically but little lost time. All kinds of pig iron will sell at prices ranging from 4 dols. to 6 dols. per ton lower than this year. Labour will be made to suffer the most in this reduction. The cost of producing pig iron in the Lehigh Valley has already been reduced to 18 dollars, and further reductions are expected. Some of the great steel interests are not regretting the slump as much as the newspapers would have it appear. The mills have been running for a year or two practically without repairs, and some of them are in rather bad shape. The present opportunity will be taken advantage of to make very extensive repairs, as well as some long postponed improvements.

Export orders are an encouraging feature just at this time. Considerable fabricated material is wanted in Porto Rico, and the State railways of Chili are in the market for 60 locomotives. An order for 1500 tons of light rails will be placed early next week for the Japanese railways. The plate manufacturers have a large volume of business on their books made up of requirements from the car builders, and this industry will suffer less than any other. Notwithstanding the generally upset condition of things, there is an enormous volume of traffic to be moved and the railways are in need of more rolling stock. They are also in need of locomotives and all kinds of rolling stock, particularly drop bottom coal cars in the sections where coal is heavily mined. Exports of copper for the week ending November 21st were 10,978 tons, and since November 1st 25,867 tons. Lake copper is quoted at 13 c., electrolytic 12⅞ c., casting 12½ c. The copper market is gradually gaining strength. Lead is dull at 4·25 here and 4·20 at St. Louis. Exports of lead this week, 1635 tons, and since November 1st 3530 tons. Spelter is weaker and there is a poor demand.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MESSRS. CROSBY LOCKWOOD AND SON announce that they are about to open at 121A, Victoria-street, Westminster, a West End branch of their business.

MR. JOHN HARDISTY, M. Inst. C.E., informs us that he has been appointed general manager for Messrs. James Milne and Son, Limited, engineers and brassfounders, Edinburgh.

THE King of Sweden has appointed Mr. F. V. H. Pegelow to be director-general of the State Railways for six years from January 1st, 1908, and Mr. V. L. Klemming to be deputy director-general for the same period.

MR. BERTRAM C. JOY, son of the late Mr. David Joy, has opened an office at Craven House, Kingsway, where he will undertake the preparation of designs in mechanical engineering, and particularly in connection with motor car work.

MR. J. ARTHUR REAVELL has resigned his position as general manager to Manlove, Alliott and Co., Limited, to join the board of the Kestner Evaporator and Engineering Company, Limited, as managing director. This company is being formed to work the English and colonial patents of the Kestner evaporator.

MICHAEL PAL AND CO. inform us that they have been appointed sole agents for the United Kingdom and the Colonies of Messrs. Louis Schwarz and Co., Actiengesellschaft, Dortmund, who manufacture low-pressure steam turbines, condensing plants, cooling towers, heat accumulators, and have special designs for cleaning efficiently blast furnace gases to be utilised for driving big gas engines.

LAUNCHES AND TRIAL TRIPS.

LYNROWAN, steel screw steamer; built by Messrs. R. Craggs and Sons; to the order of the Liver Shipping Company, Liverpool; dimensions, 374ft. by 47ft. 6in. by 24ft. 8in.; engines, triple-expansion, 24in., 41in., 67in. by 45in. stroke, pressure 180 lb.; constructed by Messrs. Blair and Co.; trial trip, November 23rd.

ELFRIDA, steel screw steamer; built by Messrs. Wood, Skinner and Co., of Bill Quay-on-Tyne; to the order of Mr. Alfred Brewis, of Newcastle-on-Tyne; engines, triple-expansion, 23in., 37½in., 61½in. by 39in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; trial trip, November 25th.

THE BIRMINGHAM ASSOCIATION OF MECHANICAL ENGINEERS.—The annual meeting of the Association will be held at the Grand Hotel, Colmore-row, on Saturday evening, December 7th. The chair will be taken at 6.45. By kind permission, arrangements have been made to visit and inspect Messrs. W. Butler and Co., Limited, Springfield Brewery, Wolverhampton, on Monday afternoon, December 9th. The party will travel by the 2.15 train—L. and N.W.R.—New-street Station, platform No. 3. Members intending to join the party will kindly notify the Secretary on or before Friday, December 6th, to enable the necessary arrangements to be made as to reduced fares, &c., also to notify Messrs. W. Butler and Co. as to the number that will be present.

THE ASSOCIATION OF WATER ENGINEERS.—The twelfth winter meeting of the Association will be held at the Geological Society's Apartments, Burlington House, W. (by kind permission of the president and council of that body) on Saturday, December 14th, 1907, when the chair will be taken by Christopher Sainty, M.I. Mech. E., president, at 10.30 o'clock a.m. A paper entitled "The Water Supply of Malvern," by Mr. W. Osborne Thorp, surveyor and waterworks engineer, Malvern; a paper entitled "Notes on the Water Supply of Paris and Suburbs," by Mr. Easton Devonshire, and a paper entitled "Underground Water: the Right of User in the light of Recent Enactments," by Mr. Alfred B. E. Blackburn, will be read and discussed. A paper on "The Influence of the Thickness of the Pipe Wall on the Rate of Discharge of Water from Minute Orifices Piercing the Pipe" will be presented by Mr. W. R. Baldwin-Wiseman.

CONTRACTS.—Messrs. J. Smart and Brown, of Erith, Kent, have just shipped to Bangkok a complete marine equipment in the form of a three-cylinder colonial engine complete with propeller shaft, &c.; also two sets to New Zealand, there being three more to follow to the same order, making eleven sets to the order of the same firm within five months. Amongst recent orders received are three twin-cylinder sets for a firm of naval contractors and other twin-cylinder sets for Russia.—Johnson and Phillips, Limited, have received orders from the Hankow Waterworks and Electric Lighting Company, Limited, of China, for the supply and erection of a complete equipment of a generating station of 1500-kilowatt capacity, and for outside mains and supplies. The same firm has also received orders for cables for the Bermondsey Electricity Department and the Neath Rural District Council, and from the Erith Urban District Council for overhead transmission line. At the present time the firm has in course of manufacture for the London, Brighton and South Coast Railway nine miles of high-tension distributor cable and nine miles of five-core special test and telephone cable.

ROYAL AGRICULTURAL SOCIETY.—In response to a cordial invitation received from the City of Newcastle-upon-Tyne, the Council of the R.A.S.E. have decided that the show of next year shall be held at Newcastle-upon-Tyne from Tuesday, June 30th, to Saturday, July 4th. The site, on the Town Moor, where the 1887 meeting was held, is about one mile distant from the Central Railway Station, and is reached by two routes of electric tramways. The prize sheet for the Newcastle Show, to be issued early in the New Year, will be of the same comprehensive nature as that provided at Lincoln this year. Towards the prizes to be offered £5000 will be contributed by the Royal Agricultural Society from its own funds, £2000 by the Newcastle Local Committee, and £300 by the Northumberland and Durham Agricultural Societies. An offer of prizes of the value of £50 and £25 has been accepted for plans of farm buildings, and the detailed conditions of competition are now under consideration. Prizes of gold and bronze medals will be offered in two classes for manure distributors for (*a*) artificial manure, and (*b*) farmyard manure. On the 31st July a large and influential deputation attended the Council meeting to invite the Society to visit the City of Gloucester in the year 1909, and it was unanimously decided to accept the invitation to hold the show of 1909 in Gloucester, subject to the Society's usual conditions being complied with.

NOTES FROM GERMANY.

(From our own Correspondent.)

The Silesian Iron Trade.

No charge of importance has had to be recorded in the condition of the iron industry recently, and no further decrease in activity has taken place. There is not much life stirring in any department, though consumers in many cases have to wait longer than they like, because some mills are still well provided with work, and a scarcity of workmen prevents their executing orders promptly. Pig iron is comparatively scarce; iron ore, too, and the Königshütte is reported to intend sending one of their managers to Spain for the purpose of buying ore mines there, home supplies in iron ore being irregular and insufficient. Prospects for improvement in the bar trade are limited. Only in the railway and engineering departments a vigorous activity is being maintained.

From the Siegerland.

The reserve among consumers has become more general, and employment is stated to have considerably decreased. Very few orders have come in during the week, and the fierce competition among the different works has caused much weakness in quotations, which is specially marked in the smaller articles of finished iron, while the prices for raw material have hitherto remained unchanged. The blast-furnace works do not announce an abatement in demand; they are well booked forward till the end of the year. Comparatively little iron ore is being bought; the blast-furnace works are not caring to buy more than what is absolutely necessary. Deliveries of the Wire Convention on home and on foreign account during last October were 20,600 t. Compared to previous months, a decrease of about 15 to 20 per cent. is shown, which falls chiefly to inland consumption.

State Railway Requirements.

Contracts worth about 300 million marks, as against 285 million marks last year, are reported shortly to be placed by the State Railway Administration. It is said that about 17,000 wagons and 1000 locomotives are to be ordered.

Coal and Coke.

The German coal market is as strong as ever, the weakening tendency in the iron business having had no influence as yet on the coal and coke industry.

Reduced Tariffs for Coal in Prussia.

The Prussian Railway Council has resolved to take steps to lessen the scarcity in pit coal that is causing so much trouble and delay. A request to limit, or totally abolish, the reduced tariff for export, and the reduced freights for the import of pit coal, coke, and briquettes, is to be put forward at a meeting on the 6th inst.

The Austrian Iron Market.

Demand shows an abatement compared with previous weeks, but employment has hitherto been regular and even brisk at some works. In Hungary the terms of delivery are very long; orders booked in November will be executed in June and July next year. Official quotations are as under:—Mixed forge pig, 130 crowns; hematite, 130 to 133 crowns; charcoal pig iron, 130 to 132 crowns p.t.; ferro-manganese, 80 per cent., 340 crowns; spiegeleisen, 10 to 12 per cent. grade, 140 crowns p.t. Good merchant bars per ton, free Vienna, 230 to 240 crowns; tank plates, 310 to 320 crowns; boiler plates, 315 to 325 crowns; girders, 242 crowns; galvanised sheets, 495 crowns, all per ton free Vienna. Deliveries continue insufficient on the Austro-Hungarian coal market. From November 10th to 16th, 93,519 t. Bohemian brown coal have been delivered on the Saxon railways, which is 1645 t. less than in the same period last year. Austrian output of pit coal in October of present year was 11·96 million q., against 11·37 million q. in September of present year. Total output of brown coal in October was 21·68 million q., against 21·57 million q. in the month before. On the whole, 34·65 million q. coal were produced last month, as compared with 32·94 million q. during September.

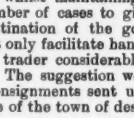
Downward Movement in Belgium.

There has been no special feature of interest during the past week to report. Prospects are rather clouded, and present employment is far from good. Some works have been compelled by the steady decrease in the iron industry to stop one or two days per week, and in the Charleroi district a general reduction in wages up to 10 per cent. came into force on the first of the month. The Belgian coal market is tending to weakness. In house coal an active trade is done, in spite of the unusually mild weather; some sorts have advanced in price. Coal for industrial purposes, however, is in decreasing request, in consequence of the dulness in the iron and glass industry, and as the Belgian iron trade consumes about one-fifth, or 18 per cent., of the total production in coal, the reduced activity in the iron industry will be keenly felt on the coal market.

Depressing Accounts from France.

Demand has fallen off considerably, and secures but an insufficient employment for the works. The French coal market, on the other hand, is firm, engine as well as house coal meeting with good demand.

THE CONSIGNMENT MARK ON GOODS.—Much inconvenience and sometimes loss is caused to traders by reason of delay in the delivery of goods, or of their misdelivery. In some instances the delay or misdelivery is the result of negligence on the part of the railway company's servants; in others it is due to negligence on the part of the servants of the trader; and in others it is undoubtedly the result of insufficient direction. It is of the last we desire to say a few words. It is a very general custom to consign goods under mark, and without any address or indication of their destination; so that if a package gets separated from its invoice, there is no information upon it to enable railway officials to know what to do with it. Everyone having the slightest acquaintance with the immense volume of traffic, involving thousands of separate consignments, passing daily over the railway system will realise the possibility of packages going astray, and the consequent difficulty of getting them to their proper station, owing to the want of address. There are, of course, substantial reasons for the practice of consigning goods under mark, but it is worth while considering whether, whilst maintaining this practice, it is not possible in a large number of cases to give some more distinctive indication of the destination of the goods. If it is, then we believe that it will not only facilitate handling by the railway companies, but save the trader considerable trouble and complaint from his customers. The suggestion we have to make is that in every possible case consignments sent under mark should also be marked with the name of the town of destination, thus:—



We believe this would be welcomed by the railway companies, and that if it were generally adopted it would greatly facilitate the distribution and delivery of traffic.—*Birmingham Chamber of Commerce Journal.*

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS**, *M.I.Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

25,191. November 8th, 1906.—IMPROVEMENTS IN OR RELATING TO SPRAYING APPARATUS, Sir John I. Thornycroft, Knight, F.R.S., of Church Wharf, Chiswick.

This invention relates to apparatus for spraying purposes, more particularly for supplying liquid fuel to furnaces such as those of steam generators and the like. In order that liquid fuel may be utilised successfully, it is necessary to spray it or cause it to be delivered in a state of very fine division into the furnace in which it is to be burnt, and this has hitherto been generally done by intermingling a jet of steam or of air with a small stream of the fuel. The object of this invention is to avoid the necessity of using steam, air, or other fluid under pressure in the treatment of the liquid, and to attain the proper division of the fuel by forcing the same through a nozzle of special construction which at the same time renders the supply of fuel more easily controllable. There are seven figures. Fig. 1 is partly a central section. Fig. 7 is a cross section of the plug and nozzle; *a* is the casing or body from which the oil fuel, introduced through an inlet pipe *b*, is to be

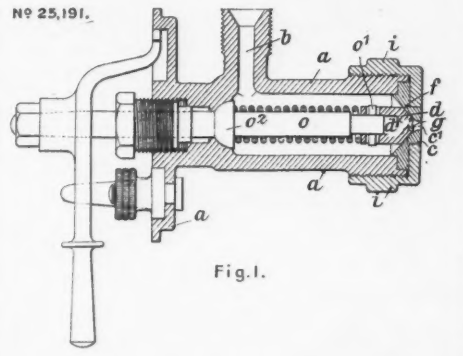


Fig. 1.

discharged through the nozzle *c*; *d* is the adjustable plug of the nozzle, having its front end portion of truncated conical shape and its rear or base portion of cylindrical shape. The conical end of the plug is formed with three helical surfaces *f*, each terminating in a step *g* that is inclined to an imaginary line connecting corresponding diameters at the base and apex end of the truncated cone. Each helical surface *f* and step *g* can be formed by mounting the plug in a holder, by which it can be rotated in a step manner and simultaneously advanced to a small extent and causing a slotting tool to pass endways over and take a cut from the conical end of the plug in the required angular direction of the step after each rotary and forward movement, so that the successive strokes of the tool cut deeper and deeper into the surface of the conical extremity of the plug, thereby forming the helical surface *f*, and finally finishing when a step *g* of the required width

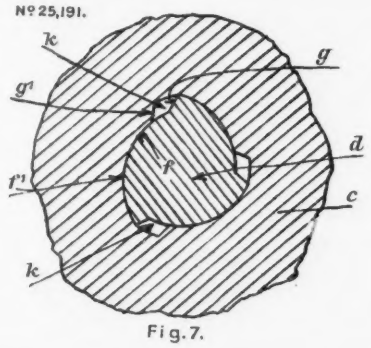


Fig. 7.

of face is formed. As the cutting is effected in a direction inclined to the imaginary line, each helical surface *f* will be slightly concave. The inner surface of the nozzle *c* is similarly formed with corresponding helical surfaces f^1 and steps g^1, so that the surfaces and steps on the one part closely fit those on the other. The forward end of the plug *d* is preferably formed with a central cavity d^1, and the nozzle *c* is formed with a centrally arranged exit aperture c^1 of circular section; *i* is a cap or ring screwed on to the casing *a* so as to hold the nozzle *c* in place therein. The arrangement is such that as the plug *d* is partially rotated in the nozzle *c*, the stepped portions *g* of the plug and g^1 of the nozzle, which are normally in contact, when the oil supply is arrested, will recede one from the other and form longitudinally extending exit passages *k*, as shown in Fig. 7, through which the oil will flow in an inclined or tangential direction from the casing *a* of the apparatus to the exit aperture c^1, where it will impinge at an angle against the wall of the aperture, so that a rotary motion will be imparted to it, and will thence escape over the outer edge of the aperture in the form of a thin hollow body, and finally break up into a finely divided state or spray.—*November 15th*, 1907.

INTERNAL COMBUSTION ENGINES.

21,254. 25th September, 1906.—IMPROVEMENTS IN OR RELATING TO INTERNAL COMBUSTION ENGINES, Otto. L. Borner, and the Diesel Engine Company, Limited, both of 179, Queen Victoria-street, London.

This invention relates to internal combustion engines operating on a two-stroke cycle. In many forms of engine of this type, the exhaust port in the engine cylinder has been arranged more or less in line with and opposite the air and gas inlet port or ports, so that with the aid of a deflector upon the engine piston, either the air or gas, or both, has or have been caused to encounter the products of combustion at the time the exhaust port remains open, the object being to cause the entering charge to assist in expelling the products of combustion without becoming materially commingled therewith. There are two figures. Fig. 1 is a part sectional elevation of a portion of the cylinder and piston. A jacketed cylinder 1 of ordinary construction is provided with a main inlet passage 2 and, directly opposite, with an exhaust passage 3, the lower side of the passages being both substantially in the same plane as the top of the piston 4 when the latter is in its lowest position or end of its working stroke; 5 is the ordinary deflecter upon the top of the piston 4 for diverting the flow of the charge as it enters the cylinder through the main inlet passage 2. Within the top cover 1^a of the cylinder is an auxiliary inlet 6 that is connected, as through a pipe or passage 6^a and a main supply pipe 7, to the chamber from which the charge to be used is

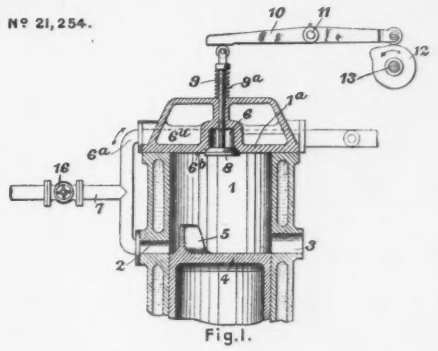


Fig. 1.

obtained. The inlet 6 is provided with a seating 6^b and a co-acting valve 8, the stem 9 of which is arranged to be moved inward against the action of a spring 9^a to open the valve by a rocking lever 10 which is pivoted at 11 and adapted to be oscillated by a cam 12 rotated by a shaft 13. The spring 9^a is made sufficiently powerful to hold the valve 8 closed, so that the valve can only be positively opened by the lever 10 or equivalent at the required time. Leading from the supply pipe 7 is a branch pipe 15 that is connected to the main inlet passage 2. On the main supply pipe 7 is a regulating cock or valve 16 which may be operated either manually, as by a hand wheel, or automatically by a governor driven from the engine and adjusted so as only to come into action when required.—*9th November*, 1907.

TURBINES.

24,040. October 29th, 1906.—IMPROVEMENTS IN POWER TURBINES, Joseph Knight, of 4, Wesley-terrace, Holyhead, Anglesea, and Arthur F. Pearson, of Soldier's Point, Holyhead.

The main object of this invention is to construct power turbines, more particularly such as are to be driven by steam, with a view to greater economy and efficiency in working, and compactness of space. There are eleven figures. Fig. 1 is a longitudinal section. A is the inner rotating member of the turbine, fixed upon a shaft A^1, B the outer rotating member, which is carried by a hollow shaft B^1, which forms the bearings for the shaft A^1, and C, the fixed casing which surrounds the outer member. The member A is formed of a number of lengths increasing in diameter towards the outflow end. The inner surface of the outer rotating member B is shaped to correspond with the formation of the outer surface of the inner rotating member A. Vanes project both from the outer surface of each length of the rotating member A, and from the corresponding lengths of the inner surface of the rotating member B, being set to ensure that the two members will revolve in opposite directions, and the rings of the vanes of the one member alternating with those of the other. Vanes project also from the outer surface of the rotating member B, for as far back as may be required from the rear end, and corresponding vanes

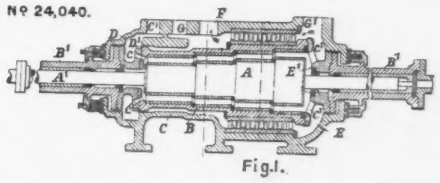


Fig. 1.

project from the inner surface of the casing C. For forward running, steam enters through the branch C^1 into a space D at the forward end D^1 of the rotating member B, and passing through openings *c* enters the annular space between the inner and outer rotating members, and passing longitudinally through the space drives such members in opposite directions of rotation, and passing out from between the rear ends of these members passes through openings c^1 of a disc E^1, which forms the rear end of the outer rotating member, into the space E behind such disc, and then returns into the rear end of the space between the outer rotating member and the casing C, and flowing back through such space increases the propelling force tending to drive the outer rotating member, and finally flows out through the exhaust branch F, and away to the condenser or atmosphere. When it is desired simply to reverse the turbine, the steam is shut off from the branch C^1, and the outlet from the branch F is closed. Steam is then admitted through a branch G into a space around the forward portion of the outer rotating member B, which is cut off from the space D, and this steam flows forward through the space between the outer rotating member and the casing C, and acting upon the vanes which project from the outer surface of such member drives it in the reverse direction of rotation. The steam used in reversing the turbine flows out from between the rear end of the outer rotating member B and the casing C into the space E, and thence through an exhaust branch G^1 to the condenser or atmosphere.—*November 13th*, 1907.

1217. January 17th, 1907.—IMPROVEMENTS IN STEAM TURBINES, James Atkinson, of Glenburn, Mellor, Stockport.

Various methods are in use for governing the power and speed of steam turbines. A very common arrangement is to throttle the steam admission, largely used because of its simplicity, although it is well known that it causes considerable loss on medium or light loads owing to the drop between the boiler pressure and that at which it enters the turbine, this drop being very largely wasted so far as power production is concerned. This fall of pressure in the fresh steam is employed by means of injector nozzles, adjusted to suit the conditions of working at the time, to draw partially expanded steam back from the turbine, say, from about midway between the inlet and the exhaust; this steam is then forced into the turbine, combined with the fresh steam. There are two figures. Fig. 2 shows a turbine in vertical section. If the fresh steam has passed through a suitable injector nozzle, adjusted in relation to a properly constructed induced steam nozzle, having a communication with the turbine at a place where the steam has been expanded to, say, 20 lb. absolute, a certain amount of induced steam can be drawn out of the turbine at this place, raised to the 100 lb, and again forced into the turbine to assist in

driving it. Fig. 2, Sheet 2, shows a turbine arranged to work with full loads with an appreciable proportion of induced steam. The fresh steam at full boiler pressure enters at *i*, passes down through the movable nozzle *l*, which in conjunction with the fixed inner cone *m*, causes it to issue in a regulated circular jet, which induces

Nº 1,217.

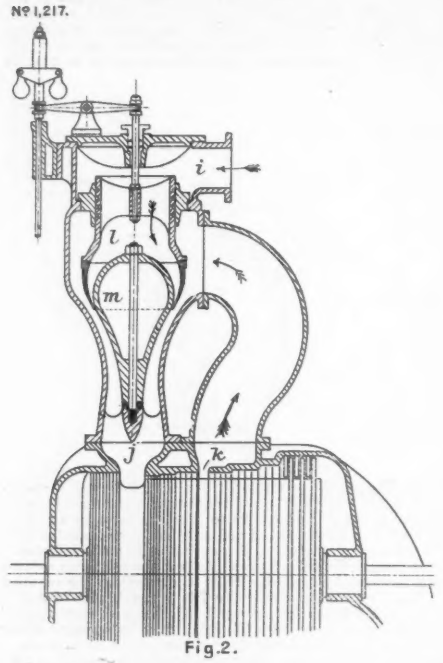


Fig.2.

steam drawn from the turbine at *k*, after it has done some work and is partially expanded, raising its pressure and causing it to re-enter the turbine at the inlet *j*, mixed with fresh steam; the pressure of the mixture being regulated by the position of the movable nozzle *l*, which also in its lowest position gives full boiler pressure.—*November 15th*, 1907.

ORDNANCE.

23,979. October 27th, 1906.—IMPROVEMENTS RELATING TO MOUNTINGS FOR BREECH-LOADING GUNS, Arthur T. Dawson, Lieutenant Royal Navy, and George T. Buckham, of Vickers, Sons and Maxim, Limited, 32, Victoria-street, S.W.

This invention relates to mountings for breech-loading guns. A pair of guns are arranged on a single centre pivot mounting so that they will both participate in the same elevating and the same traversing movements, the training gear being arranged at one side and the elevating gear at the other side of the mounting. The mounting is fitted with cross-connected sights, and the parts of the sighting gear are so arranged that the range setting is effected from the left-hand or elevating side of the mounting, and the deflection setting from the right-hand or training side. There are three figures. Fig. 2 is a plan. A A are the guns arranged side by side in a cradle B having a pair of brake and return spring cylinders B^1 B^1 situated one beneath each gun. The cradle is trunnioned in a single centre pivot, which is mounted in the pedestal D. D^1 is the worm wheel with which the pedestal is provided and with which engages a worm adapted

Nº 23,979.

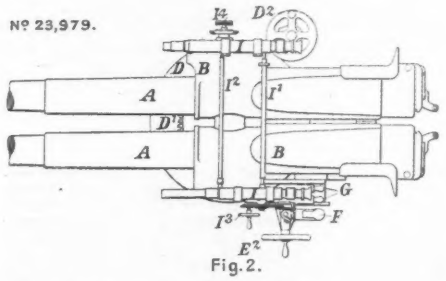


Fig.2.

to be actuated by the training hand wheel D^2 for training the guns in the ordinary way. At the side of the mounting opposite to the training hand wheel D^2 is situated the elevating rack E, which is fixed to the cradle and receives its motion for changing the elevation of the guns by gearing actuated by the elevating hand wheel E^2, which is carried by a bracket E^1 attached to the centre pivot. The training gear is at the right-hand side of the mounting, and the elevating gear at the left-hand side. F is the shoulder piece or crutch arranged at the left-hand side of the mounting, and G G are two pistol grips, also arranged at the left-hand side of the mounting and adapted to fire both guns simultaneously or one gun independently of the other. The breech blocks are of the swinging type, and are adapted to swing about their pivots in opposite directions by the actuation of the breech-actuating handles H H. I I are the sights, which are of the telescopic kind and cross-connected by rods I^1 I^2, so that they will move simultaneously in setting them for range or deflection, the range setting being effected from the left-hand side of the mounting by actuating the range hand wheel I^3, and the setting for deflection being effected from the right-hand side by actuating the deflection band wheel I^4.—*November 10th*, 1907.

ROAD MOTOR VEHICLES.

19,500. August 31st, 1906.—IMPROVEMENTS IN CLUTCHES, Arthur S. F. Robinson, of the White House, Barsham, Beccles, Suffolk.

This invention relates to friction clutches of the coil type in which the coiled band is a flexible rope—for example, a hemp or steel wire rope. The coil is connected at both ends to one of the two parts of the clutch, and is adapted to be more or less wound so as to grip the other part by suitably pulling on one end or both ends or an intermediate part of the coil. There are six figures. Fig. 1 is a central vertical longitudinal section. The shaft *a*, which may be the driving or the driven shaft, has fixed to it a double flanged drum *b*, at the end of the shaft *a* is the end of a shaft *c*, on which is mounted a disc or drum *d* having at a point near its periphery a stud *e* to which the eye *f* of a rope *g* is fixed. A oppositely placed guide pulley *i* mounted in jaws *k* attached to the disc *d* guides the rope *g*, after it has been coiled one or more times round the drum *b*, so that its other end can be passed through a hole *m* in the disc *d* and a guide tube j^1 fixed to a sliding sleeve *o*, the end of the rope being attached by a clamping nut *n* and washer plate n^1. The sleeve *o* is connected to the disc *d* by a sliding pin *t* and is carried partly by a cylindrical boss *p* arranged within an annular recess *q* in the boss *r* of the disc *d* and partly by an outwardly extending portion or boss *s* sliding on the shaft *c*. The arrangement is such that the rope *g* on the drum *b* can be rendered sufficiently slack for the drum to revolve freely within it by sliding the sleeve *o* inwardly, but, on moving the sliding sleeve

Nº 19,500.

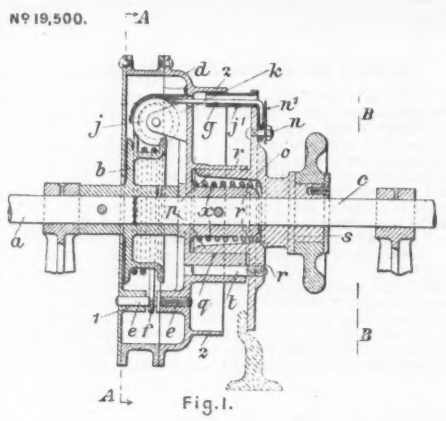


Fig.1.

o outwardly, the rope *g* is tightened and a powerful grip drive is immediately transmitted (but with sufficient slip as the coil tightens to prevent shock) through the drum *b* to the fixed end *f* of the rope on the disc *d*. The cylindrical boss *p* of the sliding sleeve *o* fits the annular recess *q* in the boss *r* of the disc *d*, so that the rate at which air can be drawn into the dashpot so formed regulates the rate at which the sliding sleeve *o* can be drawn outwardly to throw in the clutch. A spring *x* may be placed within the dashpot *q*, the spring being adapted to press the sliding sleeve *o* outwardly and tighten the coil of the rope *g* around the drum *b*, the coil being slackened by pressing inwardly the sleeve *o* against the action of the spring *x* by hand, as in the example illustrated, or by foot gear.—*November 15th*, 1907.

133. January 2nd, 1907.—IMPROVEMENTS IN APPARATUS FOR TRANSMITTING POWER FROM ONE SHAFT TO ANOTHER, *Paul A. J. E. Japy*, 18, *Rue Mogador, Paris*.

This invention relates to apparatus for transmitting the power from a driving shaft to a driven shaft of motor vehicles of the type wherein the driving shaft is provided with centrifugal blades for increasing the pressure of and throwing a liquid on to the driven system. In an apparatus constructed according to the present invention the centrifugal blades mounted on the driving shaft form guides between them leading the fluid to receiving blades, which are arranged centrepetally, and have the same object as the

Nº 133.

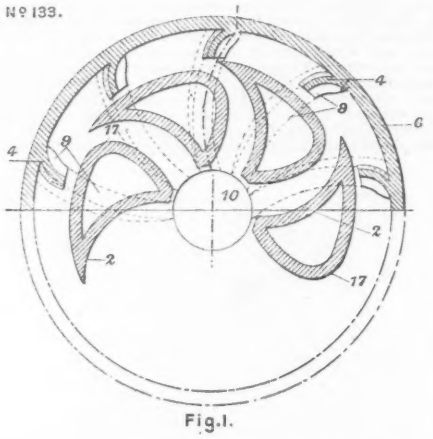


Fig.1.

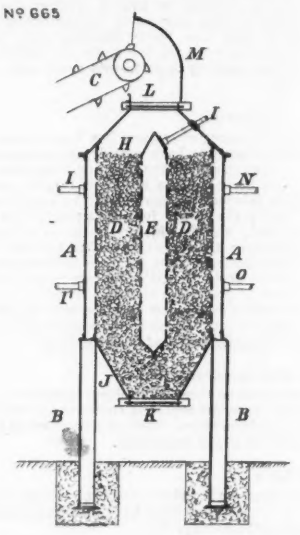
blades of the rotary member of a turbine. There are two figures. Fig. 1 is an end view partly in section. The shaft of the motor carries a system of centrifugal blades 2, which throw off a liquid on to a system of centrepetal blades 4, which are integral with the shaft of the vehicle. These blades are cast with a member 6 keyed on to the shaft, and closed at the end near the shaft by a plate which is loose on the shaft. The blades 4 conduct the liquid into channels 9, which lead it to the centre of the apparatus into a central hole 10, which opens at the base of the blades 2, and the free opening of which for the passage of the liquid is controlled. A piston controlled by hand by means of a rod operated by a wheel opens the hole 10 proportionally to the work to be transmitted from the one shaft to the other. The blades 2 are provided with an arched part 17, which is constructed in such a manner that the passage left free between these blades decreases in section from the centre to the periphery.—*November 15th*, 1907.

MISCELLANEOUS.

665. January 10th, 1907.—PROCESS AND APPARATUS FOR SECURING THE READY IGNITABILITY AND CONTINUITY OF COMBUSTION OF FIXED CARBON FUELS, Benjamin H. Thwaite, of 29, Great George-street, Westminster.

This invention relates to processes, and apparatus therefor, having for their object the removal of the objections and difficulties associated with the employment of coke, anthracite, charcoal, and other fixed carbon fuels in open household and other firegrates. There are five figures. The coke, charcoal, and anthracite is broken into regularly proportioned lumps that will pass through a 1½in. diameter ring. These uniformly proportioned lumps of fixed carbon are introduced into a steel chamber or vessel, where they are subjected to a special treatment. This treatment-vessel consists of a vertical cylinder with cone-shaped terminations, having the inlet at the top and the outlet at the bottom. Fig. 1 shows a vertical section of the apparatus. The vertical steel or iron vessel A is supported on stanchions B. The coke to be treated is lifted by the elevator C and deposited into the treatment-vessel A. In order to permit the hydrocarbon and condensible vapours to approach and penetrate the coke as uniformly as possible, an internal vessel D is fitted of less diameter than the external vessel or apparatus A. A central flue E is built up of perforated plates or strong wire gauze, and also partitions F of the same material enclosing spaces by which the hydrocarbon vapour finds easy access to the coke. The central flue has a conical cap H which constitutes one of the points of entry for the hydrocarbon vapour by means of the inlet pipe I. The base of the vessel consists of an inverted truncated cone J terminating with a sliding door K, the opening of which allows the coke to fall out of the vessel. A sliding door L is provided in the coke-introducing hood M, so that a vacuum can be established, the suction effect being applied to the two pipes N and O. These pipes and the hydrocarbon or tar vapour introducing pipes are fitted with valves, arranged with levers, that permit them to be actuated from the

Nº 665



ground level. The two sliding doors K and L are also devised so as to be readily operated from the ground level. The vessel having been filled with coke, the doors K and L are closed and the valves of the vacuum pipes N and O are opened, and as perfect a vacuum as practicable is established. Then the valves or pipes N and O are closed and the valve in the tar vapour inlet pipes I and I^1 are opened, allowing the entrance of the tar vapour, which continues to flow until the vacuum is destroyed. The introduction of the tar vapour is continued until a pressure is established, then the tar vapour inlet is shut off until the pressure gauge shows that the whole of the tar vapour has entered into and condensed inside the pores of the coke. The door L is now opened, and the treated coke is allowed to fall from the vessel and removed to a suitable storage place.—*November 15th*, 1907.

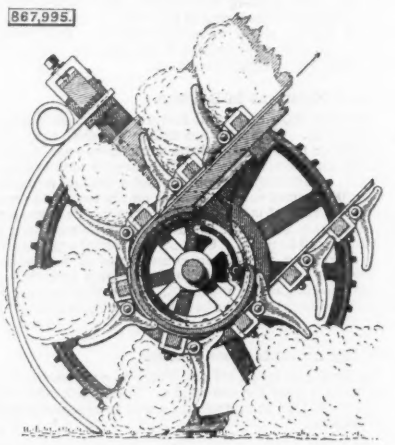
SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

867,995. CONVEYING DEVICE, *J. D. Musser, Easton, Ohio.—Filed September 17th*, 1906.

This invention is for the use of movable hooks in conveyors

867,995.

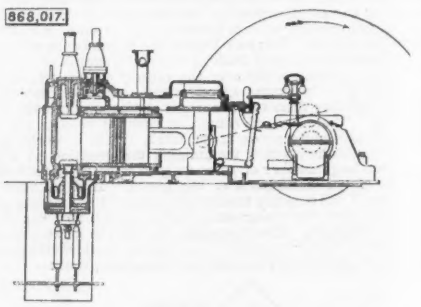


moving cotton and bulky material of all kinds. The hooks are thrown in and out of action mainly by a species of central fixed cam. There are five claims.

868,017. INTERNAL COMBUSTION ENGINE, *A. Rollason, Long Eaton, England, assignor to Robert Mond, London, England.—Filed August 28th*, 1906.

The single claim is for a single-cylinder four-stroke cycle internal combustion engine having a scavenging piston reciprocated by the piston-rod of the engine, an air valve controlling

868,017.



the admission of air to the rear of the scavenging piston which valve is held open during fully three strokes of the engine cycle and closed to cut off communication with the atmosphere only during the exhaust stroke, a combined gas and air control valve, interposed between the air-admission valve and the cylinder inlet valve, and open during the entire cycle except for a portion of the suction stroke, during which the gas valve is open.

THE ROYAL COMMISSION ON CANALS AND WATERWAYS.

No. IX.

GREAT WESTERN RAILWAY CANALS.

In the two preceding articles of this series* we dealt with the canals owned by the Lancashire and Yorkshire, Great Central, Great Northern, and London and North-Western Railway Companies, as well as the two canals controlled but not owned by the last-named company. We now turn to the evidence given on behalf of the Great Western Railway concerning canals owned by that company. The total length of these navigations is 213 miles 7 chains, and if we separate the Birmingham Canal, which is controlled, although not actually owned, by the railway, from the navigations in the possession of the London and North-Western Railway Company, the canal mileage of the Great Western Company is greater than that of any other railway in the United Kingdom.

The general manager of the Great Western, Mr. Inglis, is a member of the Royal Commission, and evidence was, therefore, given for the company by the engineer, Mr. W. W. Grierson, and the chief goods manager, Mr. T. H. Rendell.

The canals owned by the company are the following:—

	M.	Ch.
Kennet and Avon Canal—		
River Kennet	18	40
Kennet and Avon Canal	57	0
River Avon	11	0
Monmouthshire Canal—		
Pontypool section	8	75
Crumlin section	10	68
Brecon and Abergavenny Canal	33	69
Stratford-on-Avon Canal	25	50
Stourbridge Extension Canal	2	77
Swansea Canal	16	40
Bridgewater and Taunton Canal	14	40
Grand Western Canal	10	60
River Tone Navigation	0	60
Stover Canal	1	68
	213	7

The total length in the above table is as stated by Sir Herbert Jekyll in an appendix to his evidence. Mr. Grierson gives the total as 212 miles 40 chains. The first six canals mentioned in the table are controlled by a special canal engineer having his headquarters at Bath. The others, with the exception of the Stover Canal, are looked after by the company's divisional engineer at Plymouth. The Stover Canal is leased to a firm of clay merchants at Newton Abbot. Mr. Grierson stated that, with the exception of three miles at the upper end of the Swansea Canal and a mile at the upper end of the Stover Canal, all the navigations are in fair working condition, and fit to cope with a much larger volume of traffic than exists on any of them. As to the exceptions there has been no traffic on these sections for many years, and no applications for facilities. Consequently they have fallen into disuse. The Stover Canal is a non-statutory navigation, and there is no obligation on the company to maintain it.

As to water supply, on four of the canals, the Grand Western, Stover, Monmouthshire, and Brecon, there is ample water. On the Stourbridge and Stratford-on-Avon canals the supply is sufficient. The Bridgewater and Swansea canals are largely dependent on pumping, but the supply is unlimited. Finally, the Kennet and Avon Canal has a limited supply, and is dependent during the summer months on pumping; but there is frequently a shortage. On all the canals, excepting the Stourbridge, dredgers of manual, grab or bucket type, are maintained. On the Stourbridge Canal there is more water than is required, owing to mining subsidences.

The cost of maintenance of the canals has always exceeded the total receipts. Including traffic expenses, the deficit has averaged £7168 annually, and in 1906 was £11,015.

The Monmouthshire Canal came under railway control when the proprietors of the navigation converted themselves into a railway company in 1845, and constructed a railway parallel with their own canal. In 1865 the canal became amalgamated with the Brecon and Abergavenny Canal, the latter being handed over at a cost of £61,861, the original expenditure on construction being £135,450.

The Grand Western Canal is in the middle of Somersetshire, and begins at Tiverton. It cost £324,250 to construct, and ultimately passed into the possession of the Bristol and Exeter Railway's Taunton and Tiverton line—now part of the Great Western system—which runs parallel to the canal. The railway had, in a very short time after its completion, taken practically all the traffic from the canal, and the latter was acquired for the small sum of £30,640.

The Bridgewater and Taunton Canal, with the docks at Bridgewater, passed to the Bristol and Exeter Railway Company in 1865 at a cost of £74,012. The construction of the railway between 1841 and 1844 so reduced the traffic on the canal that the proprietors were unable to pay the mortgage interest, which fact led to the sale of the undertaking to the railway. The purchase price does not represent the original capital outlay on the canal, which is unknown, but must have been very great.

The Stourbridge Extension Canal* connects, by means of the Stourbridge Canal, with the Birmingham Canal and the Staffordshire and Worcester Canal. The canal cost £49,000, and was purchased by the Oxford, Worcester, and Wolverhampton Railway Company (now Great Western Railway) at cost price in 1846, as the condition of the withdrawal of the canal proprietors' opposition to the railway company's Bill then in Parliament.

The Stratford-on-Avon Canal, which originally cost £413,204, passed to the railway company at the same time as did the Stourbridge extension, for a similar reason; but in this case the purchase price was only £173,322.

The Kennet and Avon Canal and Navigations represent an original capital expenditure of £1,072,000. After the opening of the railway company's line between Reading and Bristol in 1841 the canal proprietors promoted a Bill to obtain powers to construct a railway alongside their own canal, but without success. The real object of this promotion is supposed to have been to force the railway company to purchase the canal undertaking. The construction of the Chippenham and Ironbridge Railway in 1848 still further impoverished the canal, and the proprietors sold it to the Great Western Company in 1852 for £210,415.

The Swansea Canal was constructed in 1800, and runs from the docks at Swansea alongside the river Tawe. Until 1872 the canal was in a prosperous condition and served a number of works situated on or near its banks. Between 1872 and 1881 the railway company constructed the Morriston branch line, and purchased the canal undertaking at a total cost of £147,666 in 5 per cent. preference stock, but the latter continued to make a poor revenue until the Midland Railway Company constructed branch sidings from its Swansea Valley Railway to the various works alongside the canal. Since then the traffic has steadily decreased, notwithstanding the efforts of the Great Western Company to retain the canal traffic from the Midland, until in 1905 the expenditure exceeded the receipts.

Another instance of the impossibility of canals competing with railways for coal traffic was quoted by Mr. Grierson. Before the construction of the Severn Tunnel the Bridgewater and Taunton Canal carried coal brought across the Bristol Channel from Newport to Bridgewater to the extent of 17,072 tons. Since the opening of the tunnel in 1886 this coal has been carried by rail, and the canal traffic in coal dropped gradually to 320 tons in 1905.

Mr. Grierson made a comparison between the Kennet and Avon and the Somerset Coal and Wilts and Berks canals. The two latter pass through country resembling the Kennet and Avon district, and may be regarded as similar cases. Whereas the Kennet and Avon is maintained by the Great Western Company at great loss, the two other canals—privately owned—are now derelict. The railway company is under statutory obligations to maintain all the canals belonging to it, with the exception of the Stover Canal. Had these canals remained in private or independent ownership, it is more than likely that many of them would before now have been abandoned.

Mr. Grierson's evidence on the general question of the possibility of improving the existing canals bore out what has been said by Mr. Fay and Mr. Bury in the same connection.*

On all the canals owned by the Great Western Railway the normal barge is that known as the narrow boat carrying 25 to 30 tons, but this is no reason why traders should not employ much larger boats on any of the canals if it suited them to do so.

For instance, the minimum dimensions of locks on the Kennet and Avon are 73ft. 11in. and 13ft. 11in., while the boats used by the traders are 6ft. to 7ft. wide. The normal depths on the sills is 4ft. 1in., but in summer it falls sometimes to 3ft. 4in. The railway company is not a carrier on the canals.

Mr. Rendell dealt in his evidence mainly with the traffic on the canals owned by the Great Western Railway Company. The following particulars are of interest:—

Bridgewater and Taunton Canal.—Total receipts in 1905, £1198, including tolls, £132, and dock dues and rents, £1066. Total cost of upkeep, £3960, including maintenance, £3519; rates and taxes, £152, and dredging plant, £289. Net loss on working, £2762. The canal was in an impecunious state when taken over by the railway company, and had it been left in private hands it would probably have become derelict long ago. The river Tone is a part of the Bridgewater Canal, and the tolls and expenses in connection with it are included in the canal accounts.

Kennet and Avon Navigation.—Total receipts in 1905, £3908, including tolls, £1956; rents, £1756, and wharfage, £196. Total expenditure, £10,489. Net loss on working, £6581.

Monmouthshire Canal.—Total receipts in 1905, £1749, and working expenses, £2986. Net loss on working, £1237. These figures include the Brecon and Abergavenny Canal.

Stourbridge Extension Canal.—Total receipts in 1905 £1524, and working expenses, £835, giving a net profit o £689. Since 1905 there has been a subsidence on thi

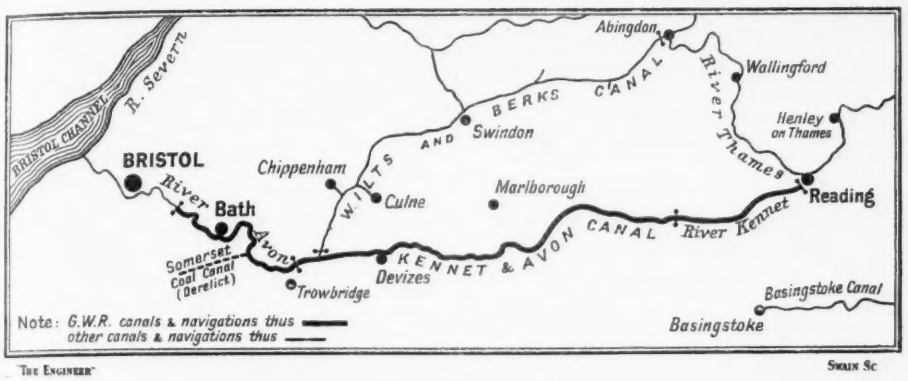


Fig. 1—KENNET AND AVON CANAL

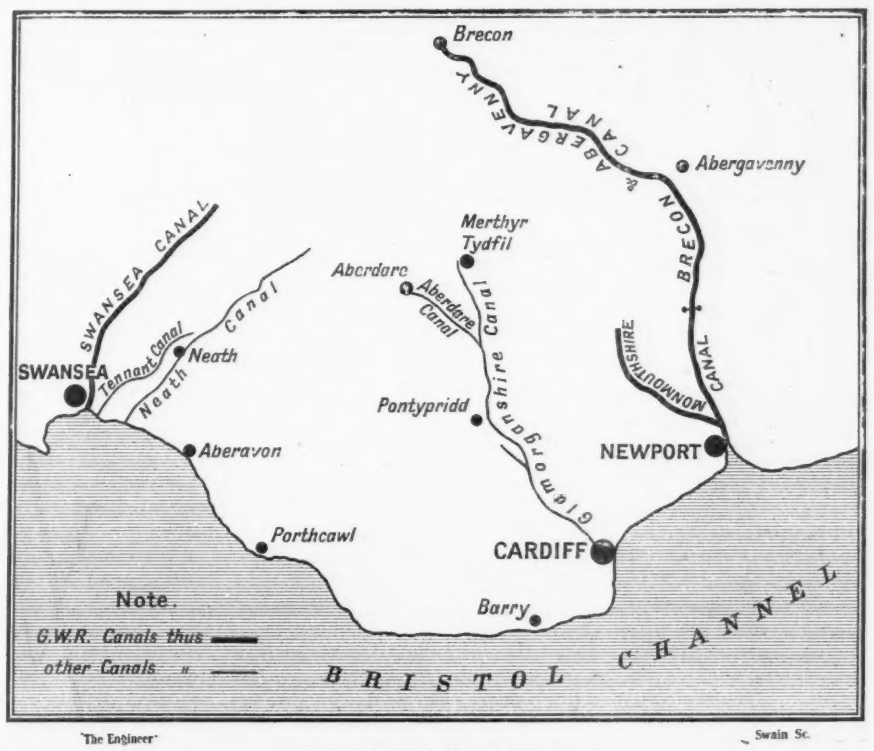


Fig. 2—THE CANALS OF SOUTH WALES

* No. VII. appeared June 14th, 1907, and No. VIII. August 2nd, 1907.

* *Vide* THE ENGINEER, August 2nd, 1907, Fig. 1.

* THE ENGINEER, June 14th.

canal entailing an expenditure of £1096, which will convert the working for 1906 into a loss.

Stratford-on-Avon Canal.—Total receipts in 1905, £1418, and working expenses, £2535, making a loss of £1117.

Swansea Canal.—Total receipts in 1905, £2560, and working expenses, £2818, giving a net loss of £258. The figures for 1906 are:—Receipts, £1182; expenditure, £2723; loss, £1541. In reference to this canal, Mr. Rendell states that since 1896 they had two strongly backed petitions from local authorities and works in the district praying the company to close the canal and convert it into a railway.

Mr. Rendell had a good deal to say in explanation of the differences between railway rates in England and abroad. Many of the English rates include services—for instance, cartage—which the foreign rates do not, and in America, as in some other countries, there is the length of haul, sometimes as much as 3000 miles. Distance for distance, he thought the English rates bore a very fair comparison with American rates. Again, the cost of railway construction in this country is naturally very much higher than abroad. The restrictions of the Board of Trade, the requirements of the municipal authorities, and the high price of land all contribute to the high cost of construction in Great Britain. He quoted the average cost in England at £54,000 per mile, in Germany it is under £21,000, and in America only £12,600. In British India, the Colonies, and in Japan the cost of construction is oftentimes even lower than in the United States. The witness confirmed what Mr. Bury* had stated in reference to large truck loads, and said that his company had found it impracticable to get traders to use wagons larger than the 10-ton unit. As to the compartment boat system advocated by Mr. Bartholomew he gave reasons why this would be quite inapplicable in the South Wales coal trade. In reference to agricultural traffic, he agreed generally with other witnesses in saying that canals could do little to help agriculturists. The Great Western had made special efforts by giving low rates for two, three, and four-ton loads with a view to inducing the agriculturists to co-operate; but there seemed to be a disinclination among the farmers to let their neighbours know what they were doing; and, of course, if they could not make up a four-ton truck load, they would not be likely to make a large load. Fig. 1 shows the Kennet and Avon Navigation and canals in connection. Fig. 2 is a map showing the South Wales canals, including those owned by the Great Western Railway.

Midland Railway Company's canals.—The only canals owned by the Midland Railway are the Ashby Canal and the Cromford Canal. Evidence was given before the Commission concerning these two navigations by Mr. Guy Granet, the general manager of the company. The Ashby Canal† was authorised in 1794 with a capital of £150,000, and borrowing powers for a further £50,000. The original canal company has the right to take water from rivers and streams within 2000 yards of the canal, and to construct reservoirs. The canal commences at a junction with the Coventry Canal at Marston, in Warwickshire, at the south end, and proceeds *viâ* Stoke, Golding, and Market Bosworth to Ashby, a total distance of about 30 miles, without any locks. It was opened for traffic in 1805. In 1846 the Midland Railway Company obtained an Act for the construction of a railway from Burton-on-Trent to Nuneaton, practically paralleling the canal all along its length. The purchase of the canal undertaking was forced upon the railway company as a condition attached to its Act, and it was acquired at a cost of £110,000. The railway company, moreover, undertook to maintain the navigation in good working order. The tolls were reduced under the Act of 1846, and again in 1894. The toll for coal from the Moira Collieries, near Ashby, going to the Oxford Canal, is now ¼d. per ton per mile. There is one tunnel on the canal at Snareston, and it is 250 yards long. The water supply is chiefly from a reservoir at Moira. The barges using the canal are of the ordinary narrow type, 70ft. to 80ft. long, 7ft. to 8ft. wide, and drawing 3ft. to 4ft. loaded. They carry from 30 to 40 tons. Most of the carrying is by private carriers, but there are a few boats owned by the collieries. The only outlet on the canal is on to the Coventry, which itself gives connections with the Oxford, Grand Junction, and Birmingham canals.

Since 1867 there has been a gradual reduction in the revenue from tolls, and now, on the average, only five to six loaded barges are to be found on the canal daily.

The cost of maintenance, apart from wages of traffic, staff, and rates and taxes has, averaged £1238 per annum for the past five years. The total outlay in 1905 was £1578, and the receipts £1181, leaving a deficiency of £397 on the year, without counting interest on capital.

Mr. Granet stated that the canal was properly dredged, and was kept in very good order.

The Cromford Canal‡ was authorised in 1789 with a capital of £46,000 and additional borrowing powers of £20,000. Authority was given to take water from the river Derwent, and the canal was opened early in the nineteenth century. In 1846 an Act was obtained for the construction of a railway from Cheadle, in Cheshire, to Ambergate, now forming part of the Midland main line to Manchester. The Act provided for the purchase of the canal by the railway company at a cost of £93,500, plus certain mortgages amounting to £10,000. The railway undertook to maintain the canal in good working order. Ultimately both railway and canal passed into the possession of the Midland Company. The canal commences at Cromford, in Derbyshire, on the north, and passes *viâ* Ambergate and Butterley, where there is a long tunnel, to Langley Mill, where it forms a junction with the Erewash Canal. The length of the canal is 14 miles 53 chains, and in addition there is a short branch of over two miles to Pinxton. The only connections with other canals are at the south end, where it joins the Erewash and Nottingham Canals. The Butterley tunnel is 3063 yards long, and in addition there are three other short tunnels on the canal. There are fourteen locks on the canal, all south-east of the Butterley tunnel, in a stretch 8 miles 39 chains in length. The locks have a depth of 3ft. over sills. The water supply of the canal is derived from the river Derwent and three reservoirs. The river supply is limited. On the wide part of the canal—that is, from Cromford to Butterley—barges 14ft. in width can be taken, and these can carry about 50 tons. On the narrow section—south of Butterley—narrow barges 70ft. in length, drawing 3ft. and carrying 20 to 25 tons, are accommodated. The maintenance expenses of the canal have averaged £1500 per annum in recent years. In 1905 the total expenses were £1785, and the corresponding total revenue £875, showing a loss on working of £910, without counting interest on capital.

Great difficulty had been experienced in connection with the Butterley tunnel, owing to subsidence due to colliery working. In 1889 the tunnel subsided to such an extent that it had to be closed, and it was only reopened in 1893 after £8000 had been spent upon it. Between 1893 and 1900 it gave much trouble, and was only kept open at great expense. In the latter year it became entirely blocked, and has remained in this condition ever since. The company recently sought parliamentary powers to abandon the tunnel, thus cutting the navigation into two distinct non-communicating portions, and to construct conduits for supplying water to the eastern section from the western section, the passage through the tunnel being blocked. The question of the proposed abandonment of the tunnel was considered at length by the Commission, and Mr. Granet stated in the course of his evidence that even when the tunnel was open there was, practically speaking, no traffic through it. The figures he furnished in support of this assertion certainly bore out his contention that it was not worth while spending £150,000 in reconstructing the tunnel. After deliberating in private, the chairman of the Commission intimated that they had decided to leave the matter of the proposed abandonment of the tunnel to Parliament and the Board of Trade.

* THE ENGINEER, June 14th.
† *Vide* THE ENGINEER, May 31st, 1907, page 541, map.
‡ *Vide* THE ENGINEER, June 14th, 1907, page 591, Fig. 2.

THE GERMAN INSTITUTION OF NAVAL ARCHITECTS.

No. III.*

A PAPER by Kais. Mar. Baurat Wellenkamp, of Kiel, described an attempt made to replace the experimental tank by a simpler and cheaper apparatus. In the experiments hitherto made in the open at the Imperial Dockyard in Kiel a freely floating model was towed by means of a weight hanging to a thin piano wire attached to the end of the bowsprit and passing over a drum into a well. The bowsprit was made as long as the model, which expedient had the effect of reducing the yawing of the latter. The method consists in the towing of the model by this weight after it has been raised to the required speed by means of an additional "starting" weight, which is considerably heavier. The towing weight is so regulated as to keep the model, thus started, in motion at a nearly uniform speed. A line is attached to the lower end of the towing weight and to a point above the highest position of the latter. The line hangs in a bight, and is so arranged as to balance the weight of the descending wire. The towing weight is made up of small weights of exactly determined amounts, which can be hung on to it as may be necessary, and the whole has to be adjusted by trial and error.

The starting weight is attached to a line which passes over the model to a sheave behind it, and then back again overhead, passing over another sheave down into the well, where a light weight is hung to it to keep it taut. The line is provided with a catch, which takes hold of the after end of the bowsprit, and afterwards lets it go again when the towing weight proper comes into play. Very finely adjusted registering apparatus, in which ingenious use is made of the vibrations of a tuning-fork in the attainment of extremely exact measurements, is provided for the determination of the resistances and speeds. A design is given for an experimental tank on this system for a vessel of 660ft. in length and a model of 33ft. The length of the tank required is stated to be about 150ft.

In the discussion that followed the first speaker, Kais. Mar. Baurat Dix undertook a defence of the experimental tank methods hitherto applied. He said the length of the tank was not 656ft. as stated, but only about 400ft. to 490ft. The ordinary towing carriage could not, he stated, cause unevenness in working. It ran at a uniform speed, and could be exactly regulated. In the older tanks which worked with towing lines a slight irregularity was caused by the sagging of these. In the new tanks which worked electrically this disturbing element was eliminated. The length of the tank was not decided by the requirements of the starting run. The exactness of measurement attained by the author of the paper—error 1 in 10,000—was indeed very great; but was this necessary, considering that the values thus obtained had to be set off graphically, when it became impossible to go to such extremes? Mr. Dix further pointed out that while two vessels of the same type and speed under the same conditions showed results differing by 5 per cent., the differences in the results of two rival experimental tanks—at Berlin and at Uebigau—did not at the higher speeds exceed 2 per cent. The speaker referred to the earlier experiments of Froude and his predecessors, and showed by the help of pictures thrown upon the screen that similar model experiments had been made in 1769 in France and in the years 1793 to 1795 in the London Docks, so that the method could not by any means be called a new one. The novelty attaching to it consisted only in the shortening of the distances over which it was applied. In this, however, lay the error of the method. By means of experiments with a model to which blades were attached at different points, he had established that, for instance, at the end of a starting run of 69ft., made at uniform speed of model, the speed with reference to the water still showed very considerable variations. If, however, measurements were taken with a short run, the point at which the speed with reference to the water became uniform was never reached. Further, the results given by the Wellenkamp method of determining the wetted surface did not agree with those of Froude's method, but showed differences of from 5 to 17 per cent., according to the speed. He was convinced, therefore, that the Froude establishments were the best. Again, the capital sunk in the dearest of these institutions brought a good return. As a result, for instance, of the work of the Berlin establishment, in connection with the last eight new vessels for the Imperial Navy, 18,000 horse-power had been saved on the amounts estimated, this representing as much as 9 per cent. on the total engine power of these vessels.

Geheimer Ober-Baurat Tjard Schwarz heartily welcomed the method of the author. It was cheap and good. The great cost of the experimental tanks lay, not in their length only, but principally in the foundations for the heavy carriage, and these would now be done away with. By this means it became possible for a small yard also to establish an experimental tank. A Wellenkamp establishment would cost M. 55,000 at the most. Uebigau had spent M. 150,000, Berlin M. 300,000, and the new naval establishment was to cost still more. The method is a very exact one, as even Herr Dix admitted. The speaker was even of opinion that it was the more exact of the two, the other one having always shown a greater resistance than the vessel herself experienced on her subsequent trials. The older method showed greater resistances than those obtained by the Wellenkamp method, and the results obtained by the latter were, in fact, the more correct.

Engineer Gebers expressed the opinion that the point of attachment of the towing wire was too high, and that the balancing by means of counter-weights was inadmissible, because the horizontal axis, about which the vessel would turn, could not be determined beforehand. He further considered that for work on the old system a tank of such large dimensions was unnecessary. The one in Uebigau was 280ft. long, but this length was necessary, not for the model towing, but for the propeller experiments. In Uebigau the starting run was 98ft., and the stopping distance 23ft. In the Wellenkamp tank the starting run had a length of only 1½ times the length of the model. Within this distance, however, the movements of the water had not yet developed themselves, and therein lay the error of the method. Now-a-days, moreover, propeller trials were necessary, and to undertake model experiments alone would be a retrograde step.

In his reply to the discussion, Herr Wellenkamp defended himself against the imputation that he had exaggerated the lengths of the modern experimental tanks, and pointed out that Herr Dix himself had proposed a length of 656ft. for the new tank now in prospect. In regard to the objection that the starting run was too short, he expressed the opinion that the water assumed its speed at the first forward movement of the model. People might laugh at the extreme accuracy of his measurements, but he must continue to maintain this to be necessary. He held that the electrical registration resorted to was too inexact, and he had, in consequence, made use of the tuning fork. He must hold to his opinion that his method was the better one, because it was the more accurate in its results and the cheaper.

*A contribution to the question of the manner of working of the screw propeller.** Paper read by Professor Oswald Flamm, Geh. Regierungsrat and Prorektor of the Königl. Techn. Hochschule zu Berlin.—This paper describes a preliminary application of a new method for determining what takes place when a screw propeller is in motion. A tank 30ft. long by 2ft. 8in. broad and 2ft. high is employed; and it has large panes of glass in its bottom and sides. A carriage runs along it on rails, and attached to the same at a suitable depth below the surface of the water is a shaft bearing the screw. The latter is actuated by an electro-motor fixed on the carriage, which thus takes the place of the vessel. The carriage is, in effect, driven by the screw, and can be made to offer greater or smaller resistance to propulsion by means of a weight attached to a wire which is led from it over a sheave fixed at the after end of the tank. Means are also provided for increasing or diminishing the speed. Pictures thrown on the screen showed the wake of the propeller, which was marked by the presence of bubbles of air, in part introduced through a small tube and in part sucked down from the surface by the screw itself. These lay in a spiral path of the same diameter as the screw itself. Kinematographic views showed the lowering of the surface of the water in a wavy line above the propeller, and a long worm-like hollow containing air behind and in a line with the boss. These pictures were particularly graphic and instructive. Professor Flamm hopes to obtain assistance from State funds or from other sources for a further development of his system.

Professor Schütte congratulated Professor Flamm on his extremely successful views. As chief of the experimental establishment in Bremerhaven, he had himself attacked the same problem in a similar manner, but being called away to another sphere of work he was obliged to leave it unsolved. Theories relating to the screw propeller were very numerous, but as we know little of what takes place within and about it, none of them are quite free from objection. The views above all things proved that no energy was lost through centrifugal action. Theory alone could not here lead us to the goal. We saw, for instance, that a propeller with an unvarying pitch, which according to theory was an absurdity, gave better results in practice than one with varying pitch. He would like to ask Professor Flamm to continue in the path he was treading, as it would certainly lead to good results.

* No. II. appeared December 6th.

* Beitrag zur Ermittelung der Wirkungsweise der schiffsschrauben.

Dr. Wagner considered the method of the author of the paper entirely free from objection. This way of investigating was much better than the one described in his own paper of two years ago, since the axial speed of the propeller could by its means be exactly determined. Further, the disturbing influence of the subsidiary phenomena is much less than by the other method. For the complete elucidation of the propeller question it was very important that the stereo-kinematic views of what took place before and abaft the propeller should be of an absolutely reliable nature. The results of experiments on a larger scale would be more accurate. It is true the cost of these would be much greater by reason of the increased length of tank required; their value would, however, be very great, and it was much to be desired that State funds might be made available for the purpose, and an experimental establishment soon called into existence.

In reply to the discussion Professor Flamm thanked the speakers for their appreciation, and hoped that the long list of problems attaching to the screw propeller would in time find their solution.

*The capsizing of vessels in launching.** By Ludwig Benjamin, Naval Architect, Hamburg. — This is an investigation into the conditions, as regards stability, of vessels in launching. When a vessel begins to take the water she gradually assumes the position in which she is borne, at the fore end by the launching ways or cradle, and at the after end by the water. Her stability under these conditions is less than when she is floating free, and may be negative. When she is caused to enter the water slowly, as is often necessary in a narrow waterway, or when she sticks during this period, or is by some mishap made to take a list, she may be in imminent danger of capsizing. Herr Benjamin investigates the case of a small vessel leaving a patent slip, and by means of diagrams of the results of a somewhat intricate calculation, illustrates the stability conditions from beginning to end of her course. He further shows that the accidents to the Daphne and other vessels which capsized in launching were probably due to the causes above referred to.

Herr Techel, in the first place, submitted an addition to Herr Benjamin's paper, which, he said, would materially facilitate the calculation of stability of a vessel in process of launching, and which bore the same relation to the vessel supported by the nose as the G M height did—for small angles of heel—to the vessel floating freely. By its means it became possible, with very few figures, to determine whether a vessel would have positive stability at inclinations of 5 deg. to 10 deg. when beginning to take the water. For greater angles, Herr Benjamin's method should then be employed. If the metacentric point were determined and connected by a straight line with the point of support of the vessel, the latter would be stable when the centre of gravity G lay below the connecting line, and unstable when it lay above it. If the length of the dangerous zone were not too great, no danger would be incurred, since the vessel glided quickly through it, as was seen every day in practice.

Geh. Ober-Baurat Schwarz heartily welcomed the paper, and asked Herr Techel also to let him have a copy of his supplementary method in order that he might apply it to the launch calculations of a large cruiser in which pressures of exceptionally great intensity had to be reckoned with. He expressed the opinion, however, that it was not only exterior wave action which might be dangerous to a vessel in launching, but to a much greater degree loose water within her. He attributed the capsize of the Iolanda to this last-mentioned cause, since the vessel was in a fully equipped condition, and would therefore have water in her boilers. He referred to the circumstance that the yacht Lensahn, belonging to H.H. the Grand Duke of Oldenburg, had heeled over to the very large angle of 30 deg. to 35 deg. in launching.

Wirkl. Geh. Ober-Baurat Rudloff remarked on the fact that the author of the paper had not given a reason for the capsize of the Iolanda. He agreed with Ober-Baurat Schwarz in his remarks with regard to the calculation, but believed that the Iolanda was too tender, as it appeared from the illustrations given that she had first floated, and then slowly heeled over till water obtained ingress into her, and caused her to capsize.

Herr Claussen had heard that in the case of the Iolanda the depth of the water had been insufficient, and that the cradle had slipped away, causing the vessel to slide over the ground, and thus producing the inclination.

In his reply Herr Benjamin first heartily welcomed the supplementary calculation of Herr Techel, which in connection with his own paper, was very valuable. He must warn people, however, against making use of this calculation alone, since it was suitable only for the initial stages of the careening motion of the vessel.

He had not gone further into the case of the Iolanda because, beyond the illustrations given, he had no particulars of her. In regard to the strictures of Ober-Baurat Schwarz, he said it was due to an oversight that he had referred only to wave action as the cause of the catastrophe; there were, of course, other possible causes. He wished, however, to point out that much too little importance was attached to the effect of wave action.

LAND RECLAMATION IN HOLLAND.

No. III.*

WHEN we consider the magnitude of the enterprise of draining the Haarlem Lake, as set out in our preceding article, we can readily excuse the President of the Commission and historian of the work for the enthusiasm shown in the following:—

"The enormous machine could at last be tried in September, 1845. It was a moment full of anxiety, but most imposing, when the colossus put for the first time in motion travelled off directly—imperfectly, it is true, but it went. That which until now had existed only in the human mind had become a reality. This mass at once, as though animated, presented itself to our gaze in its magnificent ensemble, grand, simple, strong, unique of its kind, and working grandly. Until now the Leeghwater had been but an attempt; the attempt had succeeded. What would have happened if the attempt had not succeeded? The Commission would have been blamed and contemned; this would have been the consolation of those who had dared to compromise their names in the interests of a grand undertaking. But, further, we should have expended uselessly £125,000; the drainage would have been retarded and discredited beyond measure, the Dutch name would have been despised on every hand, when it is now, because of the success of the Leeghwater machine, honoured by all who render homage to science and genius." On the 6th of November, 1845, the Leeghwater engine in full action was presented to the King. The actual drainage of the lake was not commenced until two and a-half years later; but an artificial basin was made, of the depth of 16ft. — A.P., and work from the bottom of this demonstrated the efficiency of the mechanism. In May, 1848, the lake had been finally closed, and the pumping was commenced with this engine alone, the other two not being ready for work until April, 1849.

During this whole period of eleven months the Leeghwater reduced the water level only 5¼in. In the erection of the buildings for the other machines, the "Lijnden" and the "Cruquius," the contractor found so firm a foundation and such good material at the site of the former, that a small pump worked by two horses was sufficient to keep the bed dry. At the "Cruquius," at a depth of 19ft., he struck a bed of shells from which water and quicksand poured in on every side as through a sieve. He established and maintained in action, night and day, three pumps with sixty horses, and a 6 horse-power steam pump. The deeper they sank the greater became the difficulty, until the caving-in of the whole bank became imminent. Finding the case hopeless, he announced to the President of the Commission that he had ceased a work which insurmountable obstacles rendered impossible, and asked a discharge from his contract. The reply was:—

"All means are not yet exhausted; there is room on your encircling bank for a fourth horse pump and a second steam pump. The caving-in can be prevented by sheet piling. Until the means have been tried and found insufficient, then, and then only, will *force majeure* be established. Until these have been tried the Commission cannot discharge you, and you will be immediately prosecuted for an abandonment of the work; but we will come to your aid, and will add £830 to your compensation if you immediately apply the means indicated, especially the sheet piling." An agreement was at once signed, and the next day work was resumed with unconquerable force and tenacity. The Burgomaster of the city of Leyden furnished sixty additional men; the fourth horse pump and a 10 horse-power steam pump were added. All this pumping apparatus, twelve immense pile drivers, 450 workmen and 83 horses were in full activity in and about the excavation. The top and slope of the bank were covered with sheds, shanties, stables, materials, forage; everything in movement, carting, wheeling, turning, drawing, and working, and all amidst the most cheerful songs and cries while they worked gained slowly inch by inch, in the rushing water, as the twelve pile drivers sunk the enormous piles of pine and oak.

All this activity of movement, persistent, obstinate, apparently incoherent, yet perfectly regulated—this mass of men and animals gathered in so narrow a space in the midst of water and mud—all worked together for the sole end of conquering for a few moments the effects of the natural law of water to seek its level. The skill and energy of man triumphed over Nature. Some 1700 piles, 1000 of them of oak, were covered with their heavy floor; the foundations were laid upon this, and the walls rose above the waves of the lake. The construction of these two engines with their pumps varied in no material point from that of the successful Leeghwater, but some minor modifications delayed their completion, so that only in April, 1849, did they fairly commence their work.

Every part of the machinery, as well as of the buildings to receive them, had to be originated and constructed from theoretical plans only. Some parts were made in Amsterdam, and others in England, and the erection was carried out by mechanics of both countries, who had great difficulty in understanding each other until they had invented a Dutch-English patois, unintelligible to others, but quite effective for their own purposes, and which is still the language of the pumping stations. Although the dike was made very largely of peat, the amount of infiltration due to this cause was but slight. Several formidable streams of infiltration through porous strata lying beneath the canal were, however, encountered, especially near the entrance to the Spaarne. During the early years of the polder, before these channels had become choked with sediment, they had a sensible effect on the water level of polders lying beyond the canal.

An inspecting Commission in 1860 reported that the drainage of the polder was improving year by year, and that there was no longer any serious annoyance from infiltration. As has been stated, in April, 1849, the Leeghwater had reduced the level of the lake 5¼in.; the real drainage may be said to have commenced at this point—about 31in. — A.P. From this time the lowering of the water was constant, except for a short interval during winter when the rise of the water in the outer basin required the pumps to suspend action. Early in July, 1852, the lake was dry. The whole time occupied was thirty-nine months, instead of fourteen months, as contemplated. The amount of water lifted by the pumps, which made together over 14,000,000 strokes, was over 900,000,000 tons, near 50 per cent. more than was originally contemplated. This excessive amount was due in a great degree to the infiltration, which, in all such work, is much the greatest during its early years, before the filtering beds have become filled with sediment. The removal of this greater quantity of water; the time lost in awaiting the reduction of the basin to the level at which pumping was allowed to be resumed in accordance with the contract with the Rhineland; the occasional choking of the valves of the pumps by accumulations of silt; delay amounting in the aggregate to three months for each machine, caused by accidents to their parts; and the time required to excavate the canals by which the water was led from the centre of the lake to the different pumping stations; these all combined to prolong the work, the most serious consequence of which was the addition of a large amount of interest money to the cost.

The actual time of the working of the pumps was 19½ months. The completion of the drainage of the lake was celebrated by the issue of several medals; the one struck by the Government contained a Latin inscription, which may be thus translated:—"Haarlem Lake, after having for centuries assailed the surrounding fields, to enlarge itself by their destruction, conquered at last by the force of machinery, has returned to Holland its 44,280 acres of invaded land. This work, commenced under William I., in 1839, has been finished in 1853 under the reign of William III." In 1860 it was decided that the level of the water in the polder should not be allowed to stand higher than 15½ft. — A.P. The level of the lowest part of the land is 14ft. — A.P.

The work of draining was not without its serious drawbacks. The administration of the Rhineland was flooded with complaints coming from land owners and the administrations of the polders concerning the bad effect of the work upon their established interests; petitions to the same effect were also sent to the Commission, to the King, to the States General, to the Minister of the Interior. Some of the complaints no doubt were well founded—too many of them originated in fears, misconceptions, or still worse motives. They related mainly to an undue elevation of the waters of the basin, and were met by the Commission with the general statement that the basin was no worse off in this respect than it had been before the closing of the lake; the serious dangers then existing had been removed, and that the means for accelerating the flow from the basin to the sea—the larger canal at Katwijk and the engine at Spaarndam—more than compensated for the amount of water delivered into it by the new polder.

During the whole course of its work the Commission was annoyed by innumerable complaints from every side and on every ground. Some of these were well founded, and received attention, but the majority were either chimerical or malicious, though none the less perplexing. Petitions, addresses, and complaints poured in incessantly, and divided the communities interested like petty questions of politics. The delays that arose from all causes amounted in the aggregate to about six years, but still the £670,000 appropriated for the work was not materially exceeded, so far as the items originally contemplated were concerned. The lake had been pumped out, and the excavation of the minor canals and ditches had been commenced in 1852, occupying the time until 1855, during which year the sale of the land was finally concluded. In 1856 the polder was given over to its new direction, but the pumping machine at Gouda, the last work of the Commission, was not finished until March, 1858; one month later the Commission was dissolved.

In addition to the drainage of the lake itself, it was an important part of the plan of the Commission to establish steam water-wheels at Spaarndam and halfway in the Ij to hasten the outflow of the water of the basin of the Rhineland. These accessories were believed to be necessary to compensate for the effect of winds in driving the water toward one or the other of these outlets before the lake was drained. They must also be very important to the future interests of the polders by keeping the Rhineland basin low enough for the pumps to be worked at all seasons.

The work of lifting the water is performed by a sort of reversed paddle-wheel, where the water is lifted over a dam and discharged through valve gates, opening into water at a higher level. When the wheel is not in operation the water in which it stands falls back to the inner level, and the gates are closed by the pressure of the higher water without. When the wheel is set in movement it forces the inner water over the dam, lifting it to such a height that it opens the gates and flows outward.

For some years after the first completion of the interior watercourses frequent cleaning was necessary to keep them in order. The whole mass of earth in parts of the lake was still so soft that horses could only plough with broad wooden sabots on their feet, and the slopes and beds of the watercourses were difficult to maintain in good condition. In June, 1856, the basin was in sufficiently good condition to require no further expense on the part of the Commission. The size of the polder to the interior of the encircling canal is 44,659 acres; of this, 41,648 acres are valuable land subject to taxation; the remainder is made up of roads and waterways. Canals and ditches have been dug for a length of nearly 750 miles, and roads have been made for a length of 133½ miles within the dike, and a tow-path of 37¼ miles adjoining the canal. The total length of watercourses and roadways is 919 miles.

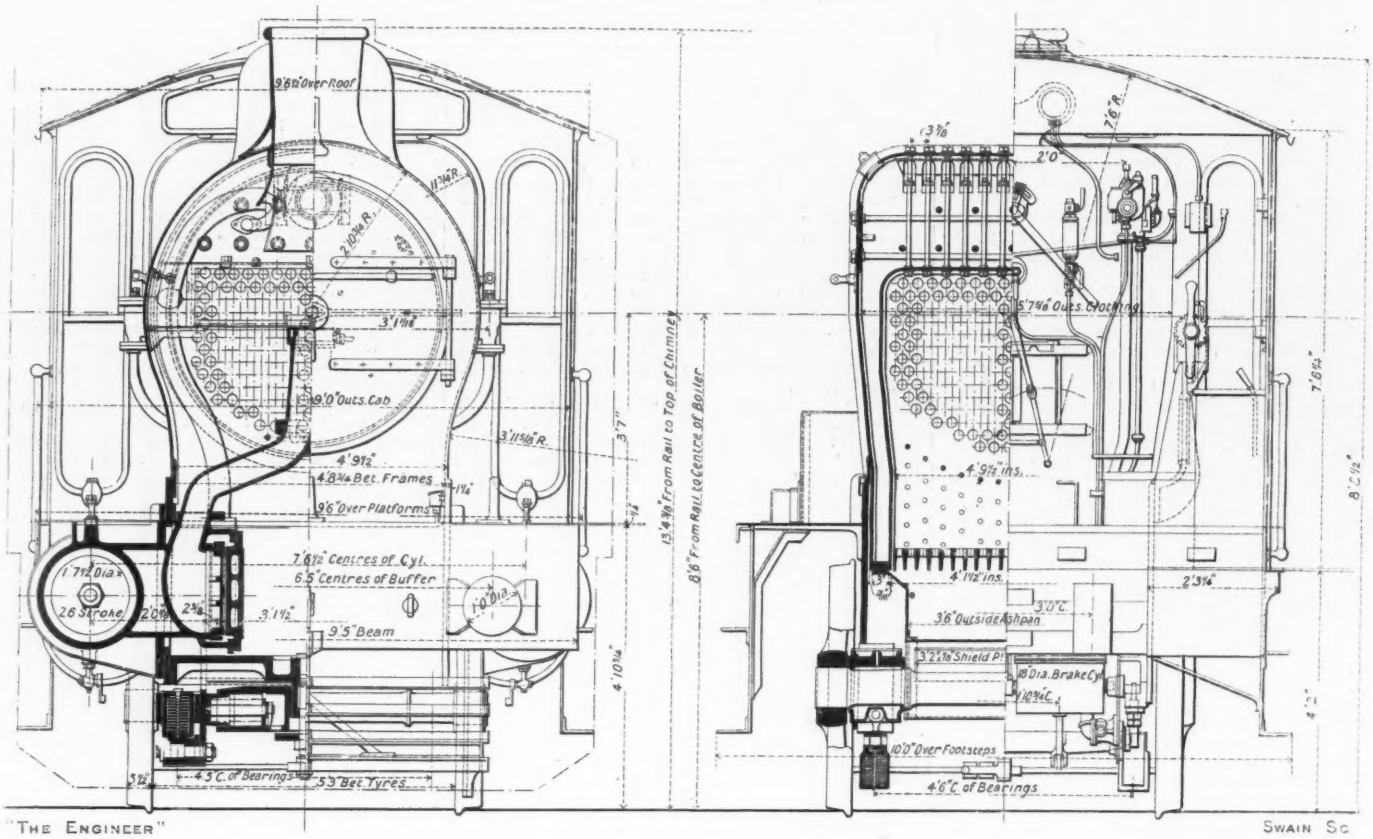
When the polder had been divided by ditches into areas of 50 acres each, and it was proposed to sell the land, an offer was made by a foreign association to buy the whole for 120 gulden per acre. There were many objections to this—an insurmountable one in the fact that those who held the bonds of the drainage loan had the right to use these at par in paying for land to be sold when the work should be completed. The first public sale took place in August, 1853, in that part of the lake over which the city of Leyden claimed ownership. In the midst of the crowd of buyers and spectators there appeared

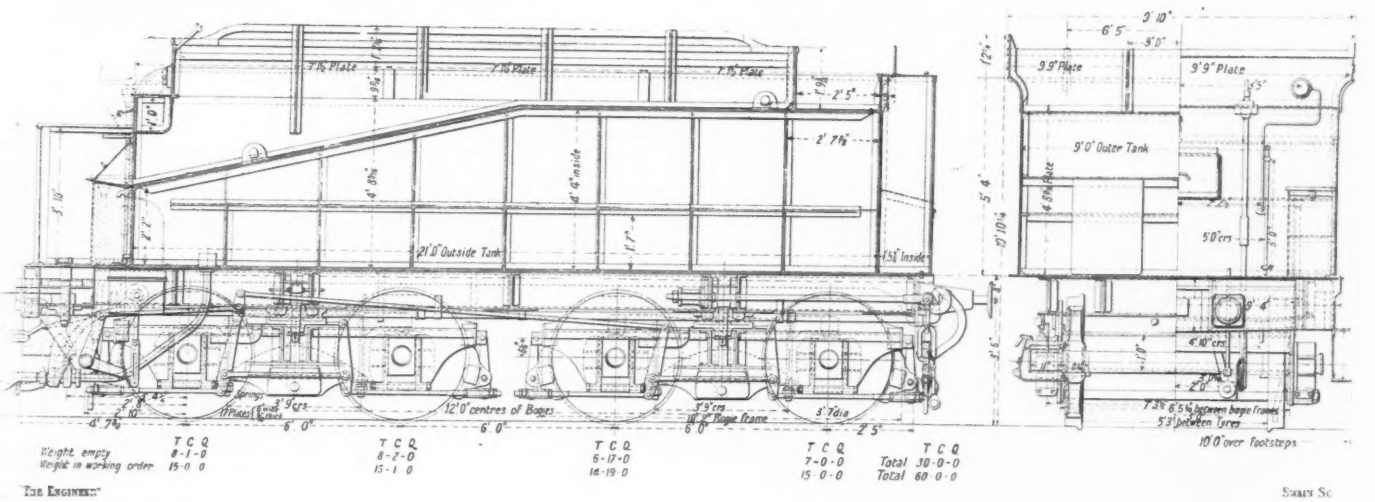
* "Das Kentern der Schiffe beim Zuwasserlassen."

* No. II. appeared November 29th.

G.I.P. RAILWAY, ATLANTIC TYPE LOCOMOTIVE—CROSS SECTIONS AND TENDER

NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, GLASGOW, ENGINEERS





an officer of the Court, who read in a loud voice the protest of the city against the sale, and threatened with prosecution any purchaser who might attempt to occupy his land. This was met by a guarantee of the Government securing all purchasers in undisturbed possession. At the last great sale of similar land which had been made it had brought 69 gulden per acre; a higher price was expected here, because of the close vicinity of several cities, and of the fact that many large proprietors in the neighbourhood would wish to increase their domains.

It had been hoped that 80 gulden would be reached. The foreign association had offered 120 gulden. To the great astonishment of all this first sale brought an average of 298 gulden per acre. Some of the land subsequently sold was less advantageously situated, and the prices were lower, but the average of the whole lake was 192·27 gulden per acre. The sum realised, together with the value of about 250 acres reserved for villages, &c., was over 8,000,000 gulden. The basin of the Rhineland—the area to receive the water pumped from the polder—as has already been stated, was reduced to about one-fifth of its original size, but no inundation of a polder has resulted from this. Many of them would have been drowned, as in 1836, if the broad basin had been in existence in February, 1860, when a fearful tempest reigned for twenty-four hours in all the land. Formerly the huge lake in prolonged storms buried half the leeward country, filling entire polders, reaching into the streets of Leyden and Haarlem, or beating at the very gates of Amsterdam. The draining has rendered such disasters for ever impossible. The effect of the wheel engine at Gouda has hardly been less important; it acts on the basin of the Rhineland by reducing the level of the Gouwe Canal, thus radically relieving all the polders which depend upon this for this outlet.

The cost of running the three steam pumps during the four years covering the time of the drainage was as follows:—

	Gulden.
Maintenance, repair, and improvements of machinery ...	80,120
Attendance	61,875
Coal	229,426
Lubricating material	20,670
	392,091

The total cost of the work from its inception until it was given over to the administration of the new polder in 1856, not including interest and commission on the loan, was 9,377,512 gulden, divided as follows:—

Works for the discharge of waters from the basin of the Rhineland (wheel engines, Katwijk Canal, &c.) ...	1,373,473
The encircling canal and dikes	1,988,257
Land purchases	684,513
Three pumping engines, and the cost of maintaining and running them	2,405,433
Works connected with the navigation of the canal and Spaarne, &c.	196,815
Works for the defence of the capital by inundation ...	275,920
The division of the polders, roads, canals, &c.	1,325,828
Repairs, &c.	434,917
Expenses of the Commission, police, lawsuits, &c. ...	644,975
Expenses not provided for in the original estimate ...	47,381

Apart from the addition of this valuable territory, with its costly works, to the taxable capital of the kingdom, the following cash returns were realised:—

Received for rents, pasture rights, sale of material, &c.	55,609
The sale of land, including the value of the small amount retained	8,032,781
Received from purchasers as pumping tax	184,187
Received for fuel, lubricants, and work at the different pumping stations on turning them over to the polder and the Rhineland	72,415
Total gulden	8,344,992

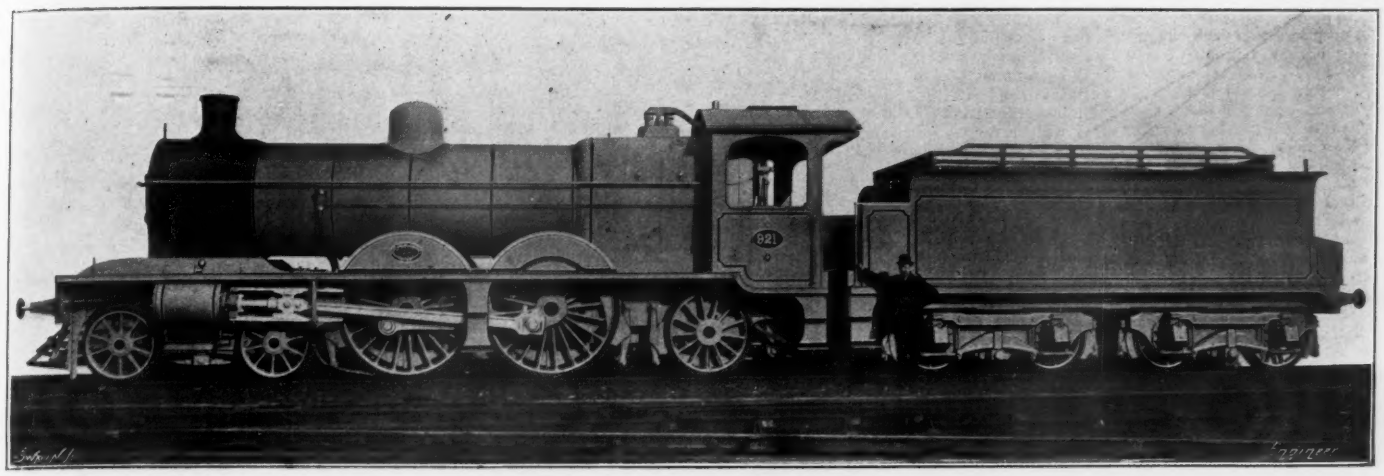
Leaving the question of interest out of the account—and much of this was due to delays for which the Commission was not responsible—the net cost of the improvement was 1,032,520 gulden, say, £83,600, less than £2 per acre for the land added to the taxable estate of the kingdom.

LOCOMOTIVE FOR THE G.I.P. RAILWAY.

THE two-page Supplement which we give this week illustrates one of the latest types of locomotives introduced into India for fast mail and passenger traffic. It has been built by the North British Locomotive Company, Limited, for the Great Indian Peninsular Railway Company, for whom the same makers are at present completing an order for forty similar locomotives with double bogie tenders under the instructions and supervision of Sir George Barclay Bruce, the consulting engineer. The engine, as will be seen from the illustration, is of the 4–4–2 ("Atlantic") type, which admits of the introduction of a boiler with large capacity for water storage and steam room, and a deep fire-box with ample grate area, the extra weight being carried on the hind pair of running wheels. The boiler is of mild steel, and is 15ft. 10¼in., between the tube plates. In most of the engines the tubes are of brass, and are 2¼in. diameter. In some of the boilers steel tubes have been fitted for experimental purposes. The fire-box is of the "Belpaire" type, having direct stays, the four front rows being flexible. The inside fire-box and the side stays are of copper. The dome is placed on the centre of the barrel, and contains the regulator, which is of the double-beat type. Four safety valves of the Ramsbottom type are fitted on the fire-box. The boiler is fed by one No. 11 combination injector and two short-stroke pumps worked by means of excentrics fixed to the leading

ATLANTIC TYPE LOCOMOTIVE, GREAT INDIAN PENINSULAR RAILWAY

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, GLASGOW, ENGINEERS



coupled axle. The cylinders are placed outside the frames, with the steam chests inside, and slide valves of the Richardson balanced type, are used. The valve motion is of the Stephenson type, with the excentric rods set to clear the leading coupled axle. Reversing is performed by screw and double-handled lever. The smoke-box is supplied with a flat spark arrester, with low blast pipe, and the chimney is prolonged downwards into the smoke-box. Steam sanding gear is fitted to the leading coupled wheels. Automatic vacuum brakes are fitted to both the engine and tender. The tender is of the double bogie type.

The following are the leading dimensions:—

ENGINE.

Cylinders, diameter	19½in.
,, stroke	26in.
Wheels, coupled, diameter	6ft. 6in.
,, bogie ,,	3ft. 6in.
,, hind ,,	4ft. 3in.
Wheel base, rigid	6ft. 9in.
,, total	27ft. 3in.
,, engine and tender, total	56ft. 1in.
Boiler barrel, mean diameter inside	4ft. 11in.
,, length	15ft. 6in.
Thickness of plates	9/16in.
Fire-box, length outside	8ft. 4⅛in.
,, width outside at bottom	4ft. 9⅛in.
,, depth at front from centre line	5ft. 8⅛in.
,, depth at back ,, ,,	4ft.
Tubes, number	201
,, diameter, external	2¼in.
Heating surface, fire-box	157 sq. ft.
,, ,, tubes	1880 sq. ft.
,, ,, total	2037 sq. ft.
Grate area	32 sq. ft.
Height of boiler from centre line	8ft. 6in.
Working pressure	180 lb. per sq. in.
Gauge	5ft. 6in.

TENDER.

Wheels, diameter	3ft. 7in.
Tank, water capacity	4500 gallons
,, coal ,,	450 cubic feet

The distributed weights of the engine and tender are:—

ENGINE.

	Tons.	cwt.	qr.
Bogie	18	7	0
Leading	17	2	0
Driving	17	7	0
Hind	13	18	0
Total in working order	66	14	0

TENDER.

	Tons.	cwt.	qr.
Front bogie	30	1	0
Hind bogie	30	4	1
Total in working order	60	5	1

THE FUTURE WATER SUPPLY OF LONDON.

No. III.*

IN the two preceding articles we have shown what are the proposals before the Metropolitan Water Board relative to the future water supply of the metropolis up to the year 1960. We have also shown that, according to estimate, it will not be economical to supply a greater quantity than 450 million gallons a day from the Thames as a source. After that time, and beyond that quantity, it will be less expensive to go further afield.

Now, it might first of all be argued that as it will be something over fifty years before London, even if its population increases at its present rate, feels the pinch of scarcity of water, nothing need be done at the moment. We are certainly in agreement as far as the actual carrying out of work is concerned. This may not be necessary for another thirty years or so; but it is a very different matter as regards the acquiring of a watershed, so that it may be available when the time comes. When that will be it is, of course, impossible to say. We have, in a former article, discussed the question of population, and shown that in 1960 it is calculated that there will be some 16,286,000 persons in the water area. The population may not increase at the rate necessary to produce a number equal to this in the intervening period, but on the other hand there is only the past to go upon, and calculating on what has happened in the past, that figure has been arrived at. The rate of past years may not be repeated in the future; London may find that it has overgrown its strength, and the rate may drop off. It, however, wants a prophet to foretell this, and the days of believable prophecy have gone by. Hence, it is certainly wise to calculate on the largest possible population, and not to sit down and say that it is impossible for London to grow any larger than it is at present.

This being so, the Water Board is certainly wise first in having gone carefully into the matter, and next in having had mapped out a course of action which, while providing an ample supply of good water, seeks to do so at the most economical rate. It was exactly the thing which the old water companies tried so hard to be allowed to do, but which they were prevented from doing by much opposition.

Watershed.	Catchment areas including compensation.	Reservoirs. Available capacity.		Top-water level.	Top-water area.	Dams. Extreme height.	Length.	Daily supply for London.
	Acres.		Million gallons.	Feet above O.D.	Acres.	Feet.	Feet.	Million gallons.
Usk and Llangorse	136,000	Usk (compensation)	6,500	733	530	120	2250	182
		Llangorse	38,000	595	2800	130	2500	
Yrfon and Towy	102,600	Yrfon	31,000	606	2850	166	4750	135
		Towy (compensation)	3,000	580	210	130	750	
Edw	17,000	Edw	4,400	700	570	80	730	18
Ithon	34,800	Ithon	9,000	900	900	120	1350	37
		Clywedog (compensat'n)	2,200	800	240	90	1100	
Upper Wye	22,000	Upper Wye	10,500	900	900	130	1100	43
Totals	312,400	For compensation	11,700	—	980	—	—	415
		For London	92,900	—	8020			
		Total	104,600	—	9000			

If additional water will, at the end of 1960, be more cheaply obtained from Wales than from the Thames, then, certainly, provision should at once be made for securing it. There are several reasons why this should be done. The first, most undoubtedly, is that if London does not soon get possession of a watershed in Wales some other town or city will do so. Already both Liverpool and Birmingham obtain their water from Wales, and their catchment areas form part of two of the areas suggested in two of the schemes mentioned in the first article. The Vyrnwy area of Liverpool was included in the area proposed by Mr. J. F. Bateman, and the Birmingham catchment area was included in Mr. Hamilton H. Fulton's scheme. Further than this, the various authorities of Wales are agitating continually for the retention of Welsh water for the use of Wales. It is not to be wondered at that this should be so; nor must it be forgotten that there are other towns a good deal nearer Wales than the metropolis which will undoubtedly before long be requiring more water, and which will naturally turn to Wales. Hence, if London wants water from Wales she must make sure of it now, or in a very short time it may be too late.

It seems to be generally accepted that it is not possible to obtain anything like an adequate supply in any other direction than Wales. The lakes of Cumberland, Westmoreland, or Lancashire have been investigated, and found not to meet requirements. Other sources which have been proposed from time to time have either been appropriated or are considered inadequate. Hence, Wales has to be fallen back upon, though it cannot be said that it has not got its drawbacks.

So far the Board has not published a definite scheme for bringing water from Wales, but the presumption is that it would embody a good part, if not the whole, of Sir Alexander Binnie's proposals. This presumption is strengthened by the fact that in comparing the relative cost of the additional 50 million gallons a day beyond the 450 million gallons, the figures taken for Wales are those which the late Sir B. Baker and Mr. G. F. Deacon arrived at when reporting on Sir Alexander Binnie's scheme. This being so, it may perhaps be of interest to recapitulate the chief features of this proposal. It suggested the acquisition of no less than seven watersheds, these being those appertaining to the Usk, Llangorse, the Yrfon, the Towy, the Edw, the Ithon, and the Upper Wye. Roughly speaking, these watersheds are bounded by a rectangle, with sides 36 by 48 miles long, though, of course, the whole of this area is not included. The figures are given, however, to show the huge nature of the scheme. The following table gives the general data with respect to the proposed storage reservoirs, &c.:—

It will be seen that the full scheme anticipates a supply to London of 415 million gallons a day, and that the minimum top-water level is 595ft. above Ordnance Datum. The idea was that there should be two aqueducts running side by side from Wales to a point some eight or nine miles south-east of Cheltenham, where they were to separate, one going to Boreham, near Elstree, where a 3200 million gallons reservoir was to be constructed, with a top water level of 312·5ft. above O.D. The other aqueduct was to lead to Banstead, where another 3200 million gallon reservoir was to be constructed, with a top water level of 300ft. above O.D.

The estimate for carrying out the whole of this scheme and for obtaining the 415 million gallons a day in one operation was £38,772,250, or at the rate of nearly £93,500 per million gallons. It is interesting to see how this amount was made up. The head works at Llangorse, Yrfon, Edw, Ithon and Wye, with their collecting and communicating conduits and compensating reservoirs, were estimated to cost £8,135,000. The aqueduct from Llangorse to Elstree was to cost £7,160,000, and that from Yrfon to Banstead £8,070,000. These together made a sum of £23,365,000. The costs put down for the terminal works at Elstree and Banstead was £4,850,000 and £5,500,000 respectively, these amounts also covering the cost of connection with existing distribution pipes. The total cost was, therefore, to be £33,715,000. To it was added 10 per cent. for contingencies, and £1,685,750 for professional and parliamentary expenses, making the whole cost £38,772,250, as above mentioned.

Sir Alexander Binnie stated, however, that it would be sufficient in the first instance to use the supply afforded by the Usk from the Llangorse Reservoir. This would

* No. II. appeared December 6th.

bring 182 million gallons a day to the Elstree Reservoir, and the cost would be about £17,500,000, or at the rate of £96,000 per million gallons. Afterwards an additional supply of 18 million gallons a day could be obtained from the Edw at a further cost of £625,500. This would bring the supply up to 200 million gallons a day at a total cost of £18,095,250, or at the rate of £90,476 per million gallons delivered.

This project was of such magnitude that, before finally adopting it, the London County Council considered it wise to submit it to the late Sir B. Baker and to Mr. G. F. Deacon, who, in a report on the matter, suggested the construction of the works in six instalments, omitting the Ithon and Clywedog reservoirs. It will be remembered that these latter in Sir Alexander's project represented a daily supply of 37 million gallons. The first three instalments represented 66⅔ million gallons a day each, and referred to the Usk and Llangorse sources, including the Edw reservoir. The total supply from the three instalments was 197 million gallons a day, and the cost was estimated at £17,447,430, as compared with Sir Alexander's estimate of £18,095,250 for 200 million gallons a day.

The fourth, fifth, and sixth instalments were to be obtained from the Wye sources—the Yrfon, Towy, and Wye. The fourth was to be 69⅔ million gallons a day, and the fifth and 6th both 66⅔ million gallons. If this portion of the project were entered upon first, it was calculated that the 200 million gallons a day might be obtained for £17,335,529. If anything, therefore, Sir B. Baker's and Mr. G. F. Deacon's figures are slightly less than those of Sir Alexander Binnie, and according to these three experts there would appear to be no doubt that some 400 million gallons would be forthcoming at the price mentioned, provided that no other city or town gets a share of the watershed before London does.

Mr. Middleton, Mr. Hunter, and Mr. Hawksley, however, made estimates, which largely exceeded the foregoing figures. Thus, Sir Alexander Binnie's estimate for the Yrfon scheme alone was £10,032,250. Mr. Middleton calculated the cost to be £20,839,243, and Mr. Hunter £20,600,551, this being the lowest estimate of the opponents of the Welsh scheme. It should be remembered that these figures were placed before the Llandaff Commission, when it was a question of whether more water should be obtained from the Thames or whether a Welsh supply should at once be sought, and naturally the opponents of the latter course would try and put the matter in its worst light. It may be added that Colonel Rathbone, the Assistant Commissioner of the Royal Commission, accepted Sir Alexander's figures, with an addition for law expenses, which brought the total up to £10,629,500. Moreover, in the opinion of the Commission an addition would have to be made for accumulated interest during the construction of the works and for pumping charges capitalised. This addition brought Colonel Rathbone's total to £15,406,781, Mr. Hunter's to £23,878,448, and Mr. Middleton's to £23,843,174.

The Commission carried the matter further than this, and ascertained that were a sum of £5,427,340 invested in 1900 at 2¾ it would defray the cost of works, commenced in 1914 and completed in 1936, for a daily additional supply of 114¼ million gallons from the Thames, whereas the sum necessary to be invested in 1900 at the same interest to pay for works in Wales to give the same daily amount of water would have been £12,184,094. It was not to be wondered at therefore that on this ground alone the Commission should refuse to go to Wales. It will be remembered that it has been shown earlier in these articles that it will not be till 1960 that it will be cheaper to go into Wales rather than to go on obtaining water from the Thames.

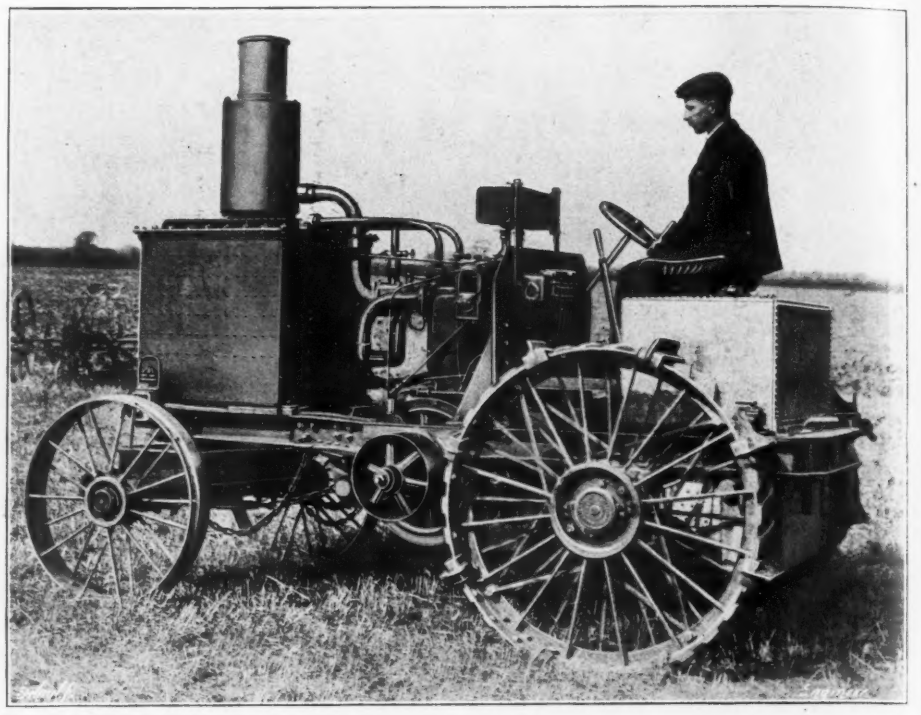
The Commission did not trouble themselves as to what would happen after 1941. This the Water Board are doing, and their proposals will, of course, necessitate the expenditure of money. Supposing that the various works in connection with the Thames can be paid for out of revenue, there will still be the purchase amount for the watershed in Wales, or wherever it is proposed to obtain it, and, as we have shown, there exists no other watershed possessing the necessary qualifications. What the sum required for this purchase will be it is impossible to say, but if we take Sir Alexander Binnie's calculation it will be necessary to acquire more than than 300,000 acres. If we suppose that these will cost an average of £10 an acre, a total of £3,000,000 will have to be expended. Now, this expenditure will be wholly for the good of those alive after 1960, and it would hardly seem fair that the present generation, the majority of whom will not be alive in 1960, should pay the whole of this amount. It will be interesting to learn, when the question has progressed a little further, how the Board proposes to deal with the matter. It is at all events known that the proposal is to obtain some return, partly by planting forests in portions of the area obtained, and partly by letting out such of the land as is suitable for farmers. We have not before us at the present moment, however, any definite figures bearing on the subject.

There are those, of course, who would rush off at once to Wales for water—who would have rushed there years ago had they been allowed. These will, no doubt, hotly oppose the retention of the Thames as a source of supply. It may be pointed out, however, that were the Thames and the Lee to be entirely discarded and Wales alone depended on the 400 million gallons obtainable from the latter source would not suffice for the needs of the metropolis beyond the year 1954. After that the rivers at present despised would have again to be drawn upon. Moreover, a supply of soft upland water would nearly certainly cause trouble with the lead distribution pipes.

Another direct railway connection between Canadian points and Pittsburg has been furnished by the opening of the new car ferry service of the Grand Trunk and Buffalo, Rochester, and Pittsburg lines, which is to cross Lake Ontario between Coburg and Rochester, and which was opened recently.

LIGHT OIL TRACTOR

MARSHALLS, SONS AND CO., LIMITED, ENGINEERS



THE SMITHFIELD CATTLE SHOW.

The annual Cattle Show, organised by the Smithfield Club, opened on Monday at the Agricultural Hall, Islington. Although there are quite as many exhibitors in the implement section as there were last year, there do not appear to be many new features in this class of machinery. Farmers are proverbially conservative, and this, no doubt, is the reason why the many excellent machines now made are the outcome of a process of slow evolution. A close examination of the different implement and machines reveals several alterations in details, alterations which in most instances tend to more rapid working, longer life, and higher efficiency, but there are very few wholly new devices.

Practically all the well-known agricultural implement makers are represented, and although their exhibits are not new departures from ordinary practice, they are nevertheless quite up to date, and well worthy of careful inspection. The feature which probably strikes the engineer most is the growing demand for small paraffin engines for all farm purposes. Although the petrol engine is quite as simple, if not more so—and it certainly takes up less room horse-power for horse-power—we noticed that the paraffin type was much more extensively employed. Inquiries elicited the statement that farmers were not so afraid of paraffin as of petrol, and under the new Workmen's Compensation Act they intended to run no risks. The Ivel Agricultural Motors, Limited, still retain a petrol engine in their motor, and we were informed that it is quite satisfactory, and so far they had had no accidents due to petrol leaking from the tanks.

Of the paraffin motors, James B. Petter and Sons, Limited, of Yeovil, have introduced 2¾ and 3½ horse-power engines, and have now a full range of their Handyman motors. Their chief feature is the vaporiser,

Fig. 1—PORTABLE AIR-COOLED ENGINE

which is so designed as to ensure proper disintegration and vaporisation of the particles of fuel, and it is claimed that it only requires about four minutes to start the engine. The smaller engines are fitted with a worm-geared slow speed shaft, which is required for driving hay and straw elevators. These are connected up to the slow-speed shaft by a tumbling bar. Saunderson and Co., Limited, of Bedford, are showing one of their universal motors of 38-50 horse-power. This machine since it was shown last year has been slightly modified; the cooler is now placed vertically, and roller bearings are used throughout. Hitherto the chassis was mounted on three wheels only, each of which was a driving wheel. The firm now makes four-wheeled chassis, and in this case also all the travelling wheels are propelling wheels. These machines are especially adapted for hauling and working threshing machines, ploughs, binders, reapers, and also for hauling road wagons. Our illustration—Fig. 1—shows an entirely new machine introduced by this firm for general farm purposes. It comprises a portable 3-4 horse-power air-cooled engine which works on paraffin oil. It is fitted with an automatic inlet valve, the exhaust valve being operated in the usual manner. The normal speed of running is 850 revolutions per minute, and through a leather to metal clutch the engine drives a two-speed cone for taking ordinary leather belts. The engine is governed. The base of the engine forms a tank, which is divided into two compartments, each capable of holding two gallons of fuel. One contains petrol and the other paraffin. We were told that the firm has been trying a 20 horse-power air-cooled motor for some time past. No particulars, however, are yet available, with the exception that it is of the four-cylinder type, and similar in many respects to the one illustrated. We hope shortly to be able to give full particulars and illustrations of this interesting tractor.

Crossley Brothers, of Manchester, have several engines on view. These are of their usual standard types, which are so well known that we need not refer to them here. There is a small 1½ horse-power petrol or benzine engine shown by this firm, which is of interest. The engine is bolted down to two longitudinal beams, which extend to take a fairly large tank for carrying the fuel and cooling water. These beams are mounted on wheels, thus forming a compact, portable plant for general farm purposes. The overall dimensions are 5ft. 6in. in length by 4ft. 5in. high by 3ft. width, and the approximate weight is 8¼ cwt. We must also draw attention to a small engine by Slipper and Co., of Brundall, Norwich, which, although not new, is not yet well known. The designer calls it an automatic engine, and this is its chief feature. Both the inlet and exhaust valves are automatically controlled in an ingenious manner. It is an ordinary four-cycle engine, built without gears, cams, or excentrics. Ignition is effected on the low-tension system, and the igniter is of the positive make-and-break type situate in the head of the cylinder, immediately at the back of the piston.

In the traction engine and tractor class, the chief feature in the Show is the new oil motor which is to be found on Marshall, Sons and Co.'s stand, and which we illustrate above. To use the firm's own words, in designing this motor they had in view an engine which would be generally useful in farm work and for all kinds of road haulage, and as regards agricultural work an engine which would practically supersede horses, so that such a machine could be used for ploughing, cultivating, hauling mowers and reapers, driving threshing machinery, chaff cutters, or any other kind of fixed machinery and for other purposes, such as driving centrifugal pumps, dynamos, stone-breakers, &c. The machine consists of a two-cylinder paraffin engine placed transversely on a channel steel frame, the water cooler being carried in front, and an extra water tank at the back end. The valves are arranged on the top of the cylinders, and worked by means of bell cranked levers from the cam shaft. The cam shaft in turn is driven by spiral gearing, and a vertical shaft from the engine crank shaft. There are three speeds—two, four, and six miles an hour—forward, and a very low speed reverse. There are two brakes. One acts on the second intermediate shaft, and the other is a hand brake, which acts upon

both hind wheels. These hind wheels are of the firm's special construction, which have proved so successful on its other types of engines. The rim and hubs are of steel, and the spokes iron. The fuel tank is carried underneath the frame near the back axle, and contains a supply sufficient, we are informed, to last for two to three days' ordinary work. Petrol is employed for starting the engine, but so soon as it becomes warm the petrol is turned off and a paraffin cock opened. The supply tank for the paraffin is maintained at a constant level by means of a small pump worked by an excentric from the cam shaft. The weight of the motor complete in working order, including the driver and water, is approximately 4½ tons. Already extensive trials have been carried out with this machine, and from the reports shown to us, the results appear to be highly satisfactory. In a twenty-four hours' non-stop run at Grayinham, in Lincolnshire, their motor recently ploughed 22 acres of land, the fuel used being 44 gallons at 6d. a gallon. The motor was hauling a six-furrow plough, and the furrows were 10in. wide by 6in. to 7in. deep, and we were told that no addition to the water supply was found to be necessary. Other manufacturers who were exhibiting the larger portable oil engines include Blackstone and Co., Limited, of Stamford; J. B. Petter and Sons, Limited; Saunderson and Co., Limited, Bedford; and also the Fairbanks Company, which has several vertical oil engines on view. The portable plant is fitted with a 6 horse-power engine mounted on a steel frame and provided with shafts to be horse-drawn.

All the well-known makers, such as Davey, Paxman and Co., Limited; Charles Burrell and Sons, Limited; W. Foster and Co., Limited; J. Fowler and Co., Limited; R. Garrett and Sons, Limited; Ruston, Proctor and Co.; and J. and H. McLaren and Co. have representative displays of their traction engines on view. Few of the two low-pressure cylinders working as in a double-cylinder engine with full boiler pressure. This arrangement provides for double the number of exhaust blasts in the chimney, and therefore ensures a better draught and brighter fire, at the same time further reducing the noise of the exhaust. Another feature of this tractor is that the machinery is enclosed in an oil-tight casing. The brackets carrying the crank shaft and second-motion shaft are formed in one casting, the bottom portion of which—together with the side frames of the engine—forms the oil bath. A small pump driven off the crank shaft circulates oil over the bearings and moving parts. The oil runs back into a reservoir at the side of the engine, from where it is again drained. With this system every working part is oiled with the exception of the hubs and two slow-running side shafts. The engine is fitted with a neat valve gear, which is practically a modification of the Joy's type. Owing to the oil-tight casing being adopted, it became necessary to alter the design of the clutch. The device now used is operated by a wheel keyed to a spindle which passes through the casing. The other end of the spindle is fitted with jaws that move the driving shaft either to the left or right, and this brings the pinions at either end of this shaft into gear with larger toothed wheels which transmit the power to the road wheels. Another new feature is the arrangement employed for locking the differential when greater adhesion is required, as when climbing steep gradients. The differential can now be locked from the footplate instead of having to stop the engine and pin the wheel, as was formerly the case. The winding drum is now carried on an independent stud and driven from the crank shaft by means of an upright shaft and bevel gear. The boiler pressure is 200lb., and the weight of the tractor empty is under five tons, so that it can be registered and used under the regulations of the Light Locomotive Act.

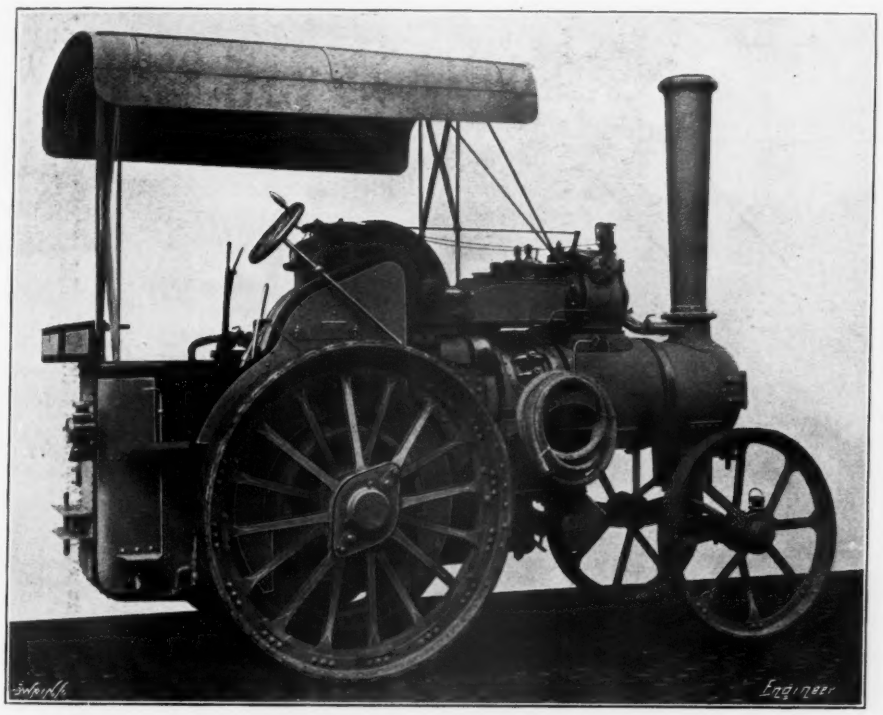


Fig. 3—LIGHT TRACTION ENGINE—JOHN FOWLER AND CO., LIMITED

makers appear to have made any departures from their previous practice; indeed, in most cases no alterations have been made at all. John Fowler and Co., Ltd., of Leeds, have introduced a new two-speed for their heavy traction engine gear, which is quite simple in design. There are two pinions keyed into the crank shaft, one of which is always in gear, with a large bevel wheel running freely on the vertical spindle, which transmits the power to the road wheel. There is a smaller bevel wheel keyed to the vertical spindle, but free to slide up and down. This is so operated by a clutch that when the bevel wheel is raised it is brought into gear with the second pinion on the crank shaft, and the engine is then on its high gear. On the under side the sliding bevel forms a kind of a dog clutch, so that when the wheel is lowered it fixes the large bevel wheel to the spindle, and the low gear is then in use. One of the latest types of light traction engines made by this firm is shown in the engraving Fig. 3.

The use of the small tractor designed to come under the Light Locomotive Act is unquestionably extending, and there are several examples of such machines to be seen. Practically all the well-known heavy traction engine makers are now also making the smaller type of road locomotive. The one which interested us most was a three-cylinder compound special spring-mounted tractor exhibited by John Fowler and Co. The high and low-pressure cylinders are alongside each other, and the other low-pressure cylinder is tandem with the high-pressure. The object of this arrangement is to increase the ratio of expansion, and equalise the power of each crank. When the starting cock for admitting high-pressure steam into the low-pressure cylinder is opened (to give the maximum power for emergencies), the engine works as a double-cylinder engine, the high-pressure cylinder being converted for the moment into a differential cylinder, the

Attention must also be drawn to the light tractor shown by Chas. Burrell and Sons, Limited, of Thetford, owing to its excellent performance in the Royal Automobile Club's trials, on which occasion it gained the gold medal. Messrs. Richard Garrett and Son's portable engine fitted with superheater, which we described and illustrated in our last issue, is attracting considerable attention amongst engineers, and is certainly one of the features of the show. Clayton and Shuttleworth, Limited, are also showing a tractor, which we dealt with last week, besides which they are showing engines of much larger size. Ruston, Proctor and Co., Limited, are exhibiting a compound traction engine, thrashing machine, clover huller, gas engine, and an extremely neat suction gas plant. There are surprisingly few suction gas plants to be found in the show, for this is certainly one of the cheapest and easiest methods of developing power, and its reliability is now beyond dispute. The Campbell Gas Engine Company, of Halifax, is showing such a plant, and also several of its engines. The same firm shows a compact little pumping plant of 1¾ horse-power. Through gearing the engine works a single ram pump, which has a capacity of 750 gallons per hour, and is designed to work against any head up to 150ft.

In the agricultural implement section the features this year appeared to be refinements rather than alterations, but we noticed at Blackstone and Co., Limited's, stand, a new side delivery rake. This is to an extent an elongated form of their swath turning device, consisting of tines similar in shape to those of a horse rake. These tines are carried on vertical and horizontal chains, travelling across the line of draught, and at the end of their travel lifting vertically out of the crop, and by a feathering motion leaving the crop in an open windrow at the side. The special point of interest is that the tines can be instantly reversed, so that the crop can be delivered on either side, The advantages of reversibility are that a windrow of any desired size may be made without planning the number of bouts required; also through being reversible it is always ready to work in any part of the field without travelling idle, and it may be set to work with the wind always in its favour. Hornsby and Sons, Limited; James Coultass; Robert Maynard, of Whittlesford, near Cambridge; J. and F. Howard, of Bedford; Ransome, Sims, and Jefferies, Limited; E. R. and F. Turner, Limited; Noxon and Co., Limited; Bamford and Sons; P. Carson and Toone; and the International Harvester Company of Great Britain, Limited, are all exhibiting representative machines indicative of the latest practice in agricultural machinery.

OBITUARY.

WILLIAM HORNSBY.

WE record with much regret the death of Mr. William Hornsby, which took place at Burwell Park, near Louth, on the 10th inst. Mr. Hornsby had been connected with the business of Richard Hornsby and Sons, Limited, during the whole of his life, first as partner in the old firm of Richard Hornsby and Sons, and subsequently as managing director when the business was turned into a limited liability company. He was born in Grantham in 1838. He was the youngest son of the late Mr. Richard Hornsby, the founder of the works at Grantham, in which town William Hornsby was born. He was educated privately and at the Wesleyan College at Sheffield.

Mr. Hornsby will be greatly missed at Grantham, where he was identified with much mupicipal and philanthropic work. He is described as being a philanthropist in every sense of the word, and no one knew the extent of his generosity. He was Mayor of his native town in 1902, having consented to take office when no one else was willing to do so, and he made one of the best mayors the town has ever known. At the end of his term of office he was pressed to become a member of Council, but owing to the state of his health he could not see his way to do so. He had, in fact, been ailing for some time, and a year ago much alarm was felt. However, he rallied until some ten days ago. He was on the Commission of the Peace for the Borough of Grantham and the Kesteven and Lindsey parts of Lincolnshire, and was Deputy Lieutenant of the County of Lincolnshire, of which county he was High Sheriff in 1898. He was a member of the Institution of Mechanical Engineers and of other kindred societies, and was closely connected with the Smithfield Club.

EDWARD SANDERSON TOZER.

THE death is announced of Mr. Edward Sanderson Tozer, which occurred at his residence, Westbourne-road, Sheffield, on the 8th inst. Mr. Tozer, who has been in failing health for a considerable time, recently underwent a serious operation, from which he never recovered. Born in 1857, the elder son of Mr. Edward Tozer, who was Mayor of Sheffield in 1879, and Master Cutler in 1875 and 1876, he was educated at the Royal Grammar School, Sheffield, and at St. Peter's School, York. He was trained for a business career, and entered the Phœnix Works, Ickles, of which his father was one of the proprietors—Messrs. Steel, Peech, and Tozer, Limited. Mr. Tozer, in due course, became a director, and the business has greatly extended, largely owing to his energy and enterprise. Outside his business, Mr. Tozer's principal interest in public affairs was in the Volunteer movement, of which he was a warm and able advocate. He joined the Sheffield Engineers as lieutenant in 1879, became Captain in 1881, major in 1896, and commandant in succession to Sir John Bingham, Bart., in 1900. The late Mr. Tozer was widely known and greatly esteemed, and his death, at the comparatively early age of fifty, is deeply regretted.

H.M.S. "SWIFT."

A VESSEL which will, it is claimed, prove when completed to be the fastest in the world was successfully launched from the shipbuilding yard of Cammell Laird and Co., Limited, Birkenhead, on Saturday last, in the presence of a large concourse of people. The Swift, the name by which the vessel will be known, is being built for the British Admiralty to meet the requirements of a special type of ocean-going torpedo boat destroyer, and is of considerably larger dimensions and higher speed than any former vessel of the destroyer class. She is designed for a speed of 36 knots per hour, as against the 33 knots of the "Tribal" class of sea-going destroyers.

Her principal dimensions are:—Length between perpendiculars, 345ft.; breadth, 34ft.; depth, 20ft. 4in., with a displacement at her mean load draught of about 1800 tons. Her armament consists of four 4in. breech-loading guns, two on the forecastle and two on the upper deck, and two 18in. torpedo tubes on the upper deck. She will be propelled by quadruple turbine machinery of the Parsons type manufactured by Cammell Laird and Co., Limited, at their Birkenhead works. As in the new large Cunard vessels, the turbines will drive four shafts, there being one propeller on each shaft. The turbines are placed in two distinct engine-rooms in order to minimise the capacity of any one water-tight compartment, and several novelties have, we are informed, been introduced in order to accommodate machinery of the large power required in the comparatively small space at disposal.

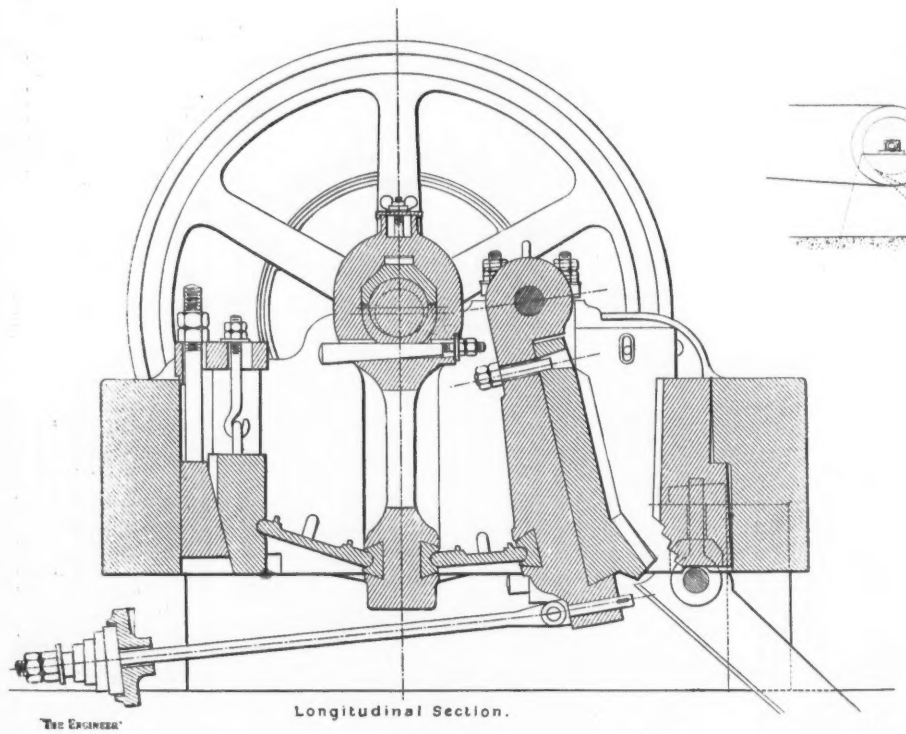
There is an installation of twelve boilers of the Express straight-tube type, these being arranged for the burning of oil fuel. The boilers have been built by the firm at their Beaufort-road works.

THE town of Tampico, in Mexico, has a population of 25,000, and has possessed an electricity supply service since 1896. Out of a plant capacity of 27,000 equivalent 8 candle-power lamps, the station has 18,000 connected and 800 consumers. The fuel used is of crude oil. There is a 10,000 volt transmission line to La Barra, ten miles distant.

A MODERN QUARRY PLANT

ORD AND MADDISON, LIMITED, DARLINGTON, ENGINEERS

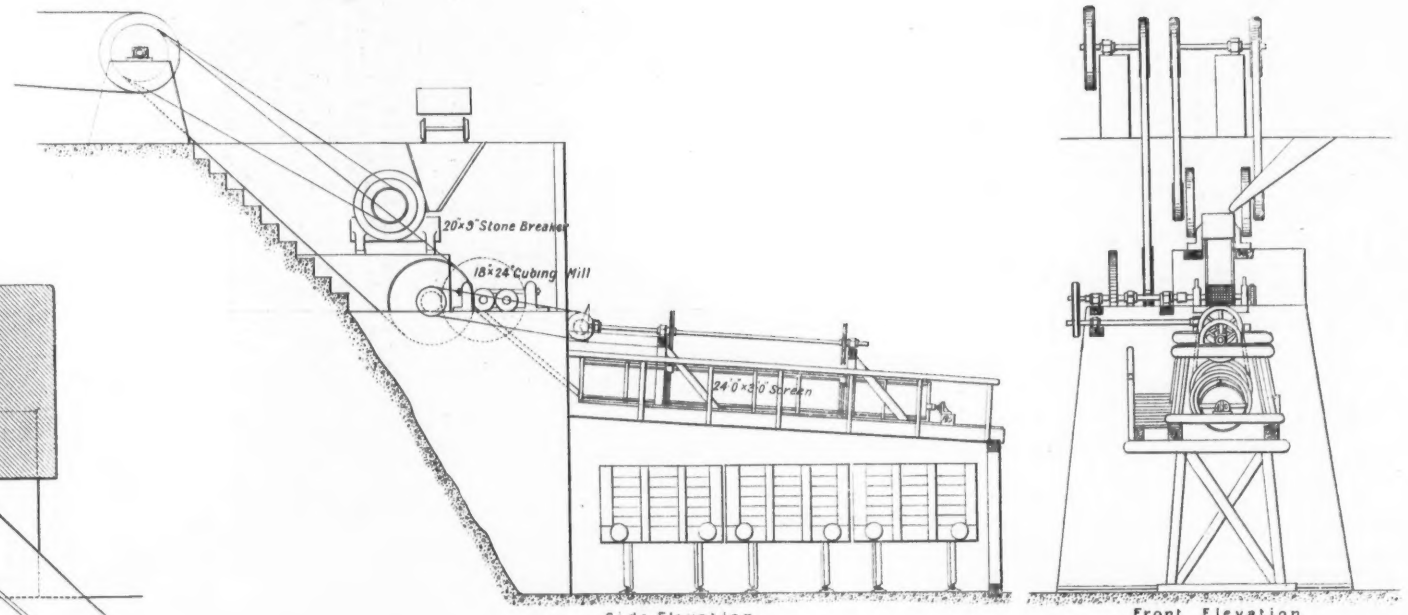
(For description see page 595)



"THE ENGINEER"

Longitudinal Section.

Fig. 1

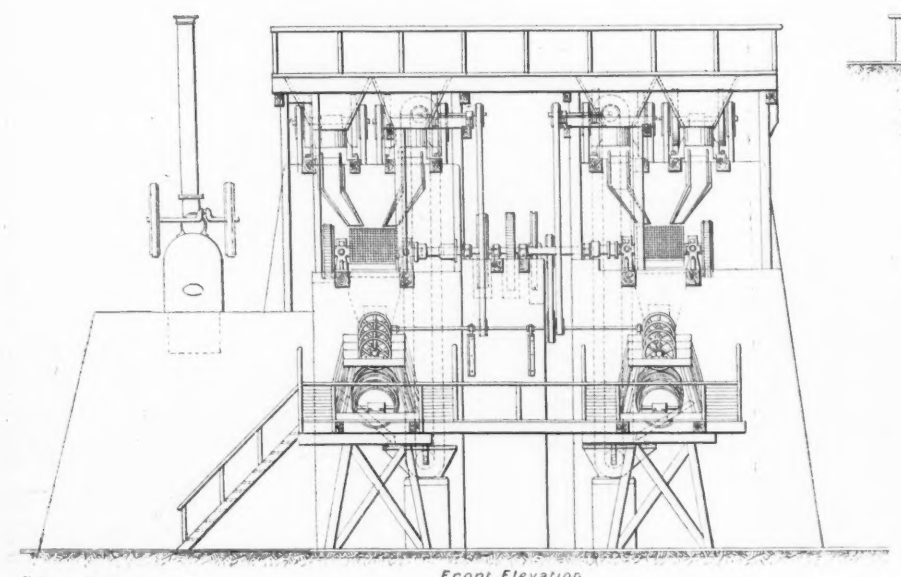


Side Elevation.

Front Elevation

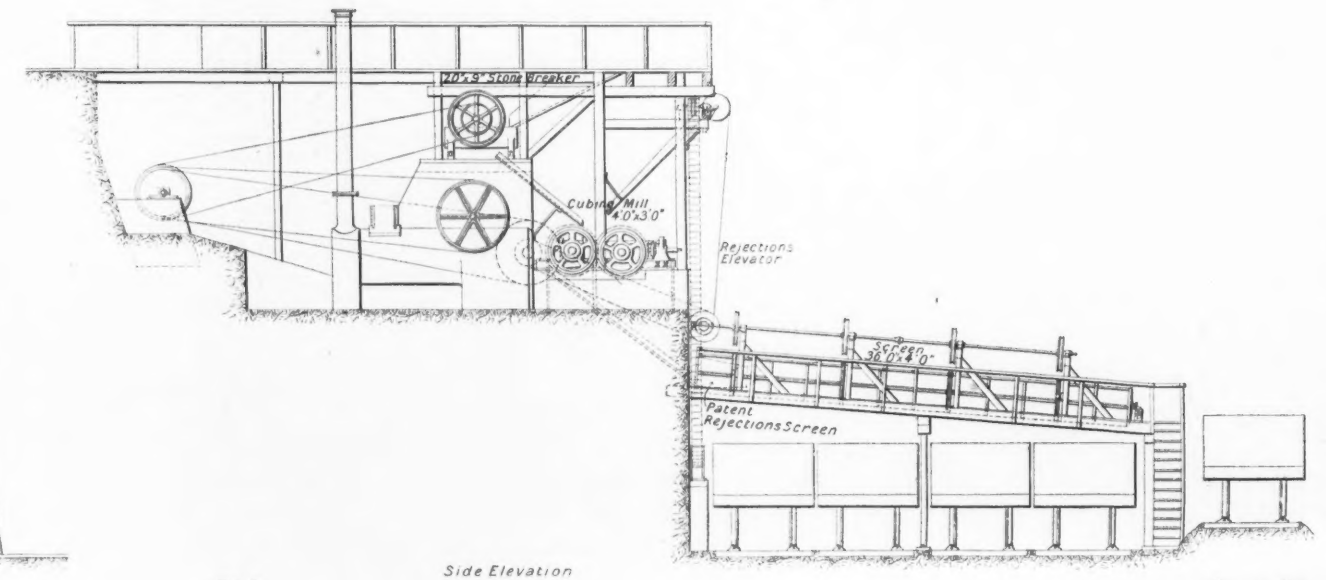
SWAIN Sc

Fig. 2



"THE ENGINEER"

Front Elevation



Side Elevation

Fig. 3

SWAIN Sc.

A MODERN QUARRY PLANT.

To John Ruskin is attributed the statement that "all social progress resolves itself into the making of new roads." Although this broad statement, coupled with other considerations, may have been once considered generally acceptable, at the present day the public is probably more particularly interested in the improvement of the surfaces of existing means of communication to render them fitted for the great developments in road transit which have followed the widespread use of self-propelled vehicles. In the formation of a durable road surface, granite—whether in the form of cubes, as largely used in towns, or broken up into smaller material as used in macadamised roads, or, again, as mixed with tar or other binding material forming a dustless pavement suitable for all kinds of wheel traffic—has qualties which render it particularly suitable for road metalling.

At the invitation of the firm of Ord and Maddison, Limited, Darlington, we recently paid a visit to Middleton-in-Teesdale, a quaint old market town in the county of Durham, close by which innumerable mountain streams converge to form the source of the river Tees. On the face of the rude granite cliffs, overlooking the North-Eastern Railway station, may be observed heaps of broken rock, a hut or two, and groups of staging. A closer inspection reveals in these unobtrusive features granite quarries of considerable magnitude. The situation is uncommon. Mountain streams provide an immense source of energy, which is utilised for driving the quarrying machinery, before they are permitted to precipitate themselves into the dale below, while the railway at the foot of the cliffs facilitates the distribution of the commercial products. The quarries are served by their own line of railway of standard gauge, their own rolling stock and locomotives, and the sidings to the quarries are so arranged that, when once the trucks for conveying away the material have been brought up empty to the highest point by the locomotives, the trucks are worked down to various places by gravity. Moreover, the machinery has been so placed that elevating mechanism is unnecessary.

There are in reality two distinct quarrying plants comprising Messrs. Ord and Maddison's latest appliances for converting the rude rocks into road material. There is also a plant for the production of tar macadam on a considerable scale. Although the amount of hydraulic power available is more than sufficient to drive the whole of the machinery employed, steam power has not yet been dispensed with entirely. A large portion of the plant is, however, driven by a 50 horse-power Gilkes turbine, the tail water from which is dammed, and afterwards serves to drive a Schiele turbine of 30 horse-power. This supplies power to a further section of the plant, and its tail water again suffices to drive a water wheel, which serves to drive a water wheel for operating the machine tools in a wagon-repairing shop.

Fig. 2 represents a side elevation and end view of the water power driven plant, which includes stone breaking, cubing, and screening mechanism. Fig. 1 represents a longitudinal section of this firm's improved 20in. by 9in. stone breaker, and Fig. 4 shows the gear-driven stone cubing mill. The screen shown is 24ft. long by 3ft. diameter, and the breaker, Fig. 1, is of the toggle motion type, simple and substantial in construction. The frame of the breaker is of cast iron composed of a tough mixture of hematite and Scotch and Cleveland irons. The horns are machined to receive a steel jaw shaft, and have phosphor bronze bushes to receive the excentric shaft. The jaw back is of cast iron of a special mixture, bolted for the jaw shaft, and fitted with cast steel toggle seat liners with dumb ends to prevent the friction of the toggles wearing away the frame sides. The fly-wheels are of cast iron turned and bored for a double belt drive. The vertical link piece is of cast steel, and has phosphor bronze bushes, cast iron keeps, and cast steel toggle seat liners. The toggle block is made of cast iron, and fitted with renewable toggle seat liners and holding-up bolt. The jaws are of a special mixture of chilled cast iron, and the cheek plates of that made by hand labour. The means of driving the screen, shown in Fig. 1 on the opposite page, is worthy of special mention. The latter is hung in chains which are carried round cast iron grooved wheels on a shaft over and parallel with the screen. The shaft is driven by bevel gearing, and the chains cause the screen to revolve by simple rolling contact with the drums, no teeth or central shaft being necessary. From the screens the broken material is deposited direct into railway trucks below, according to the mesh of the screen. The frame of the screen is made of steel T bars that made by hand labour. The means of driving the screen, shown in Fig. 1 on the opposite page, is worthy of special mention. The latter is hung in chains which are carried round cast iron grooved wheels on a shaft over and parallel with the screen. The shaft is driven by bevel gearing, and the chains cause the screen to revolve by simple rolling contact with the drums, no teeth or central shaft being necessary. From the screens the broken material is deposited direct into railway trucks below, according to the mesh of the screen. The frame of the screen is made of steel T bars and bows.

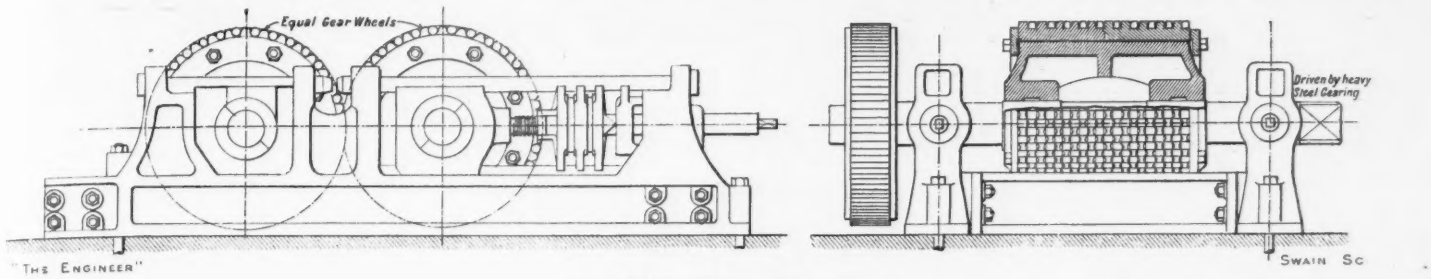


Fig. 4—STONE CUBING MILL

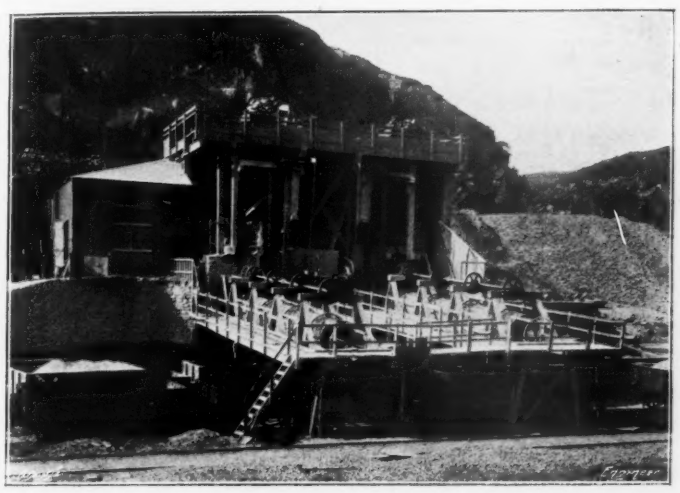


Fig. 5—STONE BREAKING PLANT

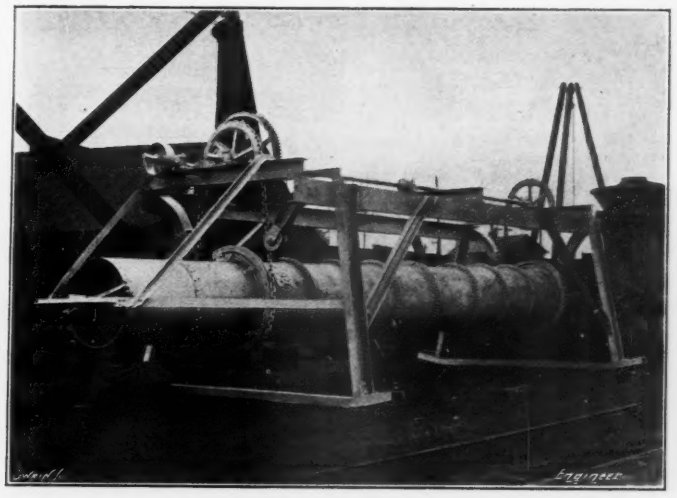


Fig. 6—REVOLVING STONE DRYER

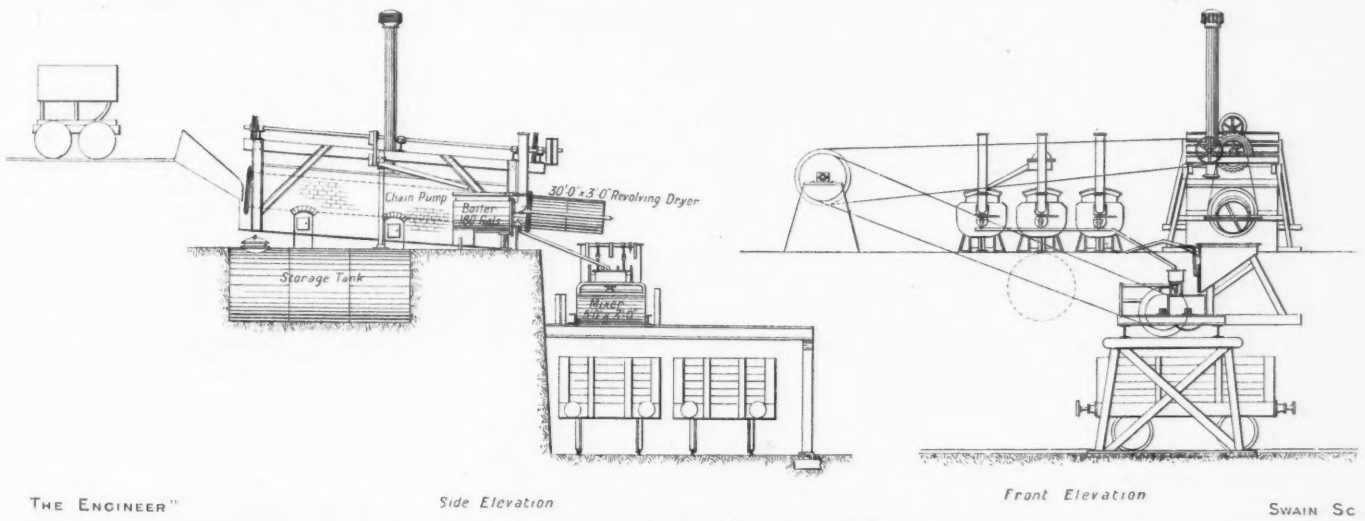


Fig. 7—TAR MACADAM DRYING AND MIXING PLANT

A general view of the second breaking, cubing, and screening plant, is given in Fig. 3, while Fig. 4 shows the details of the mechanism in side and end elevations. This is a steam-driven plant. It comprises four 20in. by 9in. breakers, two sets of 4ft. by 3ft. cubing mills, and two 4ft. patented screws

The breakers and cubing mills are all driven by double belts from a countershaft driven by the engine. A further belt gives motion to a shaft which drives the elevators for the rejected stones, and also to a shaft which operates the screens through bevel gearing. The screens are of the type described above, with an important addition. This is a new type of internal rejecting screen—Fig. 8—consisting of a perforated plate cone fitted in the higher end of the screen and rotating with it. The holes in the rejecting screen are of a diameter corresponding to the largest size of stone permissible. The stone is delivered from the cubing mills into the further and smaller end of the cone, and all pieces too large to pass through the holes into the outer revolving screen fall by gravity back into a receptacle, from which they are carried by an elevator again to the cubing rollers, where they are broken to the required size. By this means it is claimed that it is impossible for any unduly large pieces to be delivered from the screen; there are also less wear and tear, shorter screens can be used, and no additional breakers for treating the large

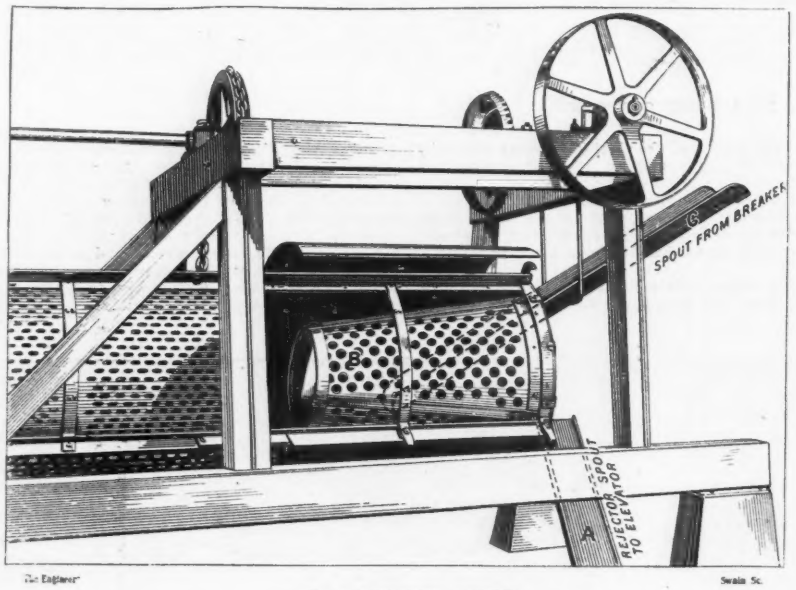


Fig. 8—REJECTOR SCREEN

rejected pieces are required. This plant absorbs about 50 brake horse-power, and requires the services of about twelve men. Its output of road-making material is about four trucks—or 32 tons per hour—and seven tons of small size material and chippings.

Fig. 7 shows very clearly the arrangement of the tar macadam drying and mixing plant, and Fig. 9 will serve to explain the action and construction of the simple mixing machine. In this plant the material, after being broken to the desired size, is tipped into the higher end of a revolving drying drum—Fig. 6—30ft. long by 3ft. diameter. The system of driving the cylinder is the same as that of the screens. The cylinder is surrounded by brickwork and heated by three small furnaces. During its progress through the tube the stone is being continually turned over and dried on all surfaces, which is essential for the satisfactory adherence

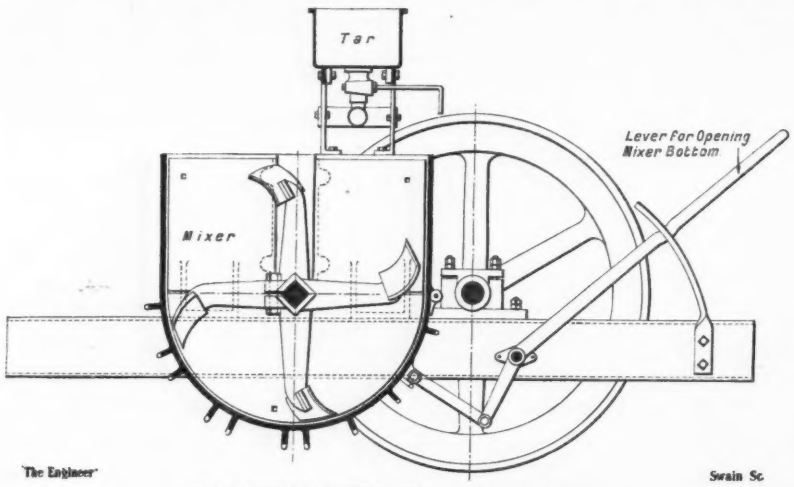


Fig. 9—SHOVEL ACTION, TAR MACADAM MIXER

of the tar to the granite. While the drying operations are being carried on the tar is pumped from a storage tank into boilers shown in Fig. 7. From the drier the material is permitted to gravitate into the mixer shown in Fig. 9, and the tar, before being admitted into the mixing machine, is drawn off into a measuring box, which is worked from the mixer platform. The mixing chamber measures 5ft. by 3ft., and is fitted with cast iron bracketed ends, which have slots to allow of the shaft and arms being lifted out for adjustment. The sides and bottom are made of cast iron plates, which are easily renewable. The door is hinged to the bottom plate, and is opened and closed by means of a lever and ratchet and quadrant from the platform. The revolving shaft in the mixer has secured to it thirteen cast steel arms. These are provided with chilled cast iron adjustable and renewable tips, which have a special formation calculated to give a thorough mixing of the solid and liquid materials. The mixer shaft is caused to revolve at a speed of about 25 revolu- per minute by means of spur gearing driven from a counter- shaft fitted with fast and loose driving pulleys and fly-wheel. When the mixing of the tar and granite has reached a complete stage the hinged door is opened and the contents are precipitated into railway trucks below. The capacity of this plant is about 120 tons per day of nine hours, and the power required for driving it is supplied by a 30 horse-power Schiele hydraulic turbine, which also drives another screening plant.

VICTORIAN RAILWAYS.

MR. TAIT, the Chief Commissioner of the Victorian Railways, who has been on a tour through England and America, returned to Melbourne a few weeks ago. He engaged an electrical expert, who is to arrive shortly, to report upon the advisability of converting the suburban railway lines to electric traction.

Owing to the past successful seasons the results of the working for the past year have shown very good. No new lines were opened during the year excepting an extension of the St. Kilda to Brighton electric street railway, which was carried to the beach, a distance of one mile. The revenue from all sources was the largest ever earned, which permitted of a larger amount being spent for the maintenance, and renewals of way and works, and repairs and renewals to rolling stock. Reductions in the rates of agricultural produce were made to the extent of £35,000 per annum.

A contract was completed during the year, which was entered into in August, 1906, for the supply of 6232 tons of 80 lb. and 100 lb. steel rails at the rate of £5 13s. 6d. per ton, delivered in trucks at the Melbourne pier, exclusive of duty. A further order for 8485 tons of steel rails has recently been let to Messrs. R. W. Cameron and Co., of New York, rails to be manufactured by the Carnegie Steel Company, the price being £6 17s. per ton, delivered in trucks on Melbourne pier, exclusive of duty. The construction of locomotives at the Newport shops has been continued. Forty-four of the "D.D." class have now been completed since the construction of these locomotives was commenced in 1903. The cost of these locomotives, on the basis fixed by the Royal Commission, is as follows:—

	Cost each. £	Cost per ton. £ s. d.
First series 10	3564	52 4 0
Second ,, ... 10	3048	47 11 0
Third ,, ... 10	2857	43 15 0
Fourth ,, ... 13	2901	44 7 10

In the make-up of the gross revenue the book-keeping method which has been in vogue for some years is still in operation, and gives an unfair advantage when comparing against any other State railway that does not get the same privilege; that is, that where Parliament considered it would be to the benefit of the country to reduce certain rates the Treasury should reimburse the Railway Commissioners the amount of loss such reduction represented.

Under this section the under-mentioned amounts have been reimbursed for the year:—For decrease in the revenue due to the carriage of agricultural produce at reduced rates, £25,000; for decrease in the revenue due to the carriage of Victorian coal at reduced rates, £7404; there is also a reimbursement of £3893 representing the enhanced cost of Victorian coal purchased during the year, owing to a direction of the Governor-in-Council fixing the price to be paid for such coals.

There are also the following expenditures provided from surplus revenue, which are not included in working expenses:—Rolling stock applied in reduction of the deficiency as at 1st July, 1903, £45,089; to credit the rolling stock replacement fund towards making good the deficiency in the rolling stock as at 1st July, 1903, £100,000; to recoup loan funds advanced prior to 1st July, 1903, for renewals of way and works and replacement of rolling stock, £20,710 7s. 10d.; a total of £165,749 7s. 10d.

Result of Working for Year 1906-7 compared with corresponding Year.

	Year ended June, 1907.	Year ended June, 1906.
Average miles open	3,335 ..	3,304
Traffic train miles	10,035,914 ..	9,802 069
Passenger journeys	No. 69,920,583 ..	65 038 394
Goods carried	tons 3,650 538 ..	3,376,987
Live stock carried	,, 315 254 ..	299 080
Gross revenue	£4,012,641 ..	3,787,619
Working expenses	£2.076,673 ..	1 999,023
Net revenue	£1,935,968 ..	1,788,596
Special expenditure and charges ..	£165,749 ..	117.542
Interest, charges and expenses ..	£1,483,284 ..	1,472,397
Surplus	£279,133 ..	198 965
Net revenue St. Kilda and Brighton Electric Railway	(loss) £7,802 ..	308

DOCKYARD NOTES.

THE German cruisers Hansa, Hertha, and Victoria Louise, and the battleship Kaiser Barbarossa, have all undergone big refits during the current year. The Barbarossa is now fitted with two very high masts, and has been a great deal cut down amidships. Four 6in. guns have been removed from the main deck.

THE German 1908 programme is announced. It is as follows:—Three "Dreadnoughts," one "Inflexible," two small cruisers of 24·5 knots, twelve destroyers of large size.

OUR programme is as follows, according to well-informed rumours:—Two "Dreadnoughts," four medium-armoured cruisers of 25 knots, one "Swift," some ocean torpedo boat destroyers. The most pronounced Radical and Socialist agitator will be hard put to it to find the "menace to Germany" in this. And according to some reports the question as to whether two or one "Dreadnoughts" shall be built is still under discussion.

A COMMISSION of French engineers—a species of Boiler Committee—recently visited England to inspect Babcock and Willcox boilers in various ships, with a view to their adoption in the "Danton" class. The Commission has now issued its report, which expresses a preference for the Belleville and Niclausse types now in use in the French navy. According to the *Moniteur de la Flotte*, the main objection to the American type of water-tube boiler lay in its extra weight compared with the French types.

THE Prince George, which recently broke adrift and impaled herself on the stem of the Shannon, is no stranger to being rammed. This is at least her third experience, the other two being from the Hannibal and from a German cruiser. A thrice-rammed ship is certainly a record not only in our own but in any other navy.

THE new Russian and Spanish battleships play hide and seek in the news columns with most interesting persistence. By the latest advices Vickers, Son and Maxim are to have a hand in the new Russians, while Beardmores are spoken of in connection with the Spaniards. As, however, it is now ten years since the Felike II. was first sketched out on paper, the odds are that the latest Spanish battleship is still the Manana.

THE *Standard*, in its campaign against the present Admiralty administration, has hit upon several points, and also, according to some people, upon several mares' nests. The latest point made is extremely novel, and, it would appear, unexpectedly true. Arguing against the Home Fleet nucleus crew idea, our contemporary put forward the proposition that, whereas under the old system of reserves these ships were ready and waiting, under the present system they are being worn out, and so will not be available in the hour of need. At first sight the argument looks rather far-fetched; but there is truth in it. The British fleet at the present time is worn to an extent that would create a panic were the real facts known. Whether it is due to the Home Fleet system or not is a moot point; for ourselves we should rather attribute it to the general *régime* of economy. The Royal dockyards are entirely unable to keep pace with repairs, while, on the other hand, the sending of any such work to the big private yards is absolutely opposed to the political principles of a large section of the present party in power. The ethics involved may or may not be right, but there is, unfortunately, no question about the result on the British Navy.

THE aluminium cell or electrolytic lightning arrester is one of the most recent developments in the field of high-tension transmission lines. The property of this cell in allowing free flow of current in one direction, and but slight flow in the opposite direction, until the applied voltage reaches a certain critical value, is used to permit static charges to be freely dissipated to the earth, while high resistance is offered to the opposite flow. Each cell will withstand 250 to 280 volts alternating, and arresters for high voltages are constructed of a multiplicity of cells with a "horn" air gap of merely sufficient opening to assist in suppressing an arc. The arrester then serves as a safety valve to the system, taking no current at the operating potential, but discharging any abnormal high potential, so that the circuit potential is not materially disturbed,

RAILWAY MATTERS.

A 1200-VOLT direct current on an overhead trolley electric railway was put into use recently by the Indianapolis and Louisville Traction Company on its line between Scottsburg and Seymour, Ind.

THE "adjusted" traffic return of the North-Eastern Railway has just been issued. It shows that the highest traffic in the first half of this year was in the week ending June 29th, and was £219,301 for that week.

ARRANGEMENTS have been made for a special express train to run on January 1st from Calais through to Chamonix. Intending passengers will leave London at 11 a.m. and reach Chamonix the next morning.

FIFTEEN locomotives fitted with Brotan water-tube boilers are in operation on the Austrian State Railways. It is stated that their performance has been so satisfactory that nineteen more engines are to be built with this type of boilers.

SANCTION has been accorded to the construction, by the Bengal and North-Western Railway, of a branch line from Madho Singh Station, on the Benares-Allahabad Railway, to the northern bank of the Ganges opposite Mirzapar—a length of 10·3 miles.

THE building of the new railway station at Lourenço Marques is, says the *Railway Times*, to start immediately. The foundations will be constructed by the railway administration and the other work put out to contract. It will probably take two years to complete.

RAILROAD sleepers for use on the lines of the Italian State Railways will in future be preserved by the Rueping process. The Government recently entered into a contract with the owners of this preservative process, whereby all of the sleepers are to be so treated.

ACCORDING to the *Review of the River Plate*, the steam turbo generator plant of the Pacific Railway Company at Bahia Blanca has proved unsatisfactory, and is to be replaced by direct-coupled reciprocating steam engines. A 1000-kilowatt unit with reciprocating engine is to be put in.

THE Gorton Council has decided to make application to the Local Government Board for sanction to borrow £11,849, the expenditure in respect of the new tramways which have been laid in Gorton-lane, Wellington-street, and Reddish-lane, which connect Stockport with Reddish, Gorton, Openshaw, and Cheetham Hill.

AT the meeting of the Barsi Light Railway Board to be held on December 17th resolutions will be submitted for the purpose of authorising the Board to construct a line of railway of the 2ft. 6in. gauge from the terminus of the company's present line at Tadwala to the town of Latur, in the territories of H.H. the Nizam of Hyderabad.

THE annual meeting of the Grand Trunk Pacific Railway Company was held last Friday morning, when several changes were made in the administration of the company, but nothing was done which will alter the policy now being pursued in constructing the transcontinental line. Of the 988 miles contracted for in the construction of the line across the Continent, 852 miles have been completed, and good progress is being made with the remainder.

ONLY nine applications were lodged during November with the Light Railway Commissioners for light railway orders—against 11 in May last—and six of these are for extensions of time, amendment of powers, &c. Of the new schemes two are electrical, viz., York Corporation—which proposes to construct six miles of line on a 3ft. 6in. gauge—and the Aluminium Company—3¾ miles to a 2ft. gauge. The total mileage proposed is 30, and the estimated cost of construction is put at £269,082.

AT Airdrie on Monday last an engine driver was tried on a charge of driving an express excursion train from Edinburgh to Glasgow recklessly, by passing danger signals at Greenside and Sunnyside, Coatbridge, on September 30th. There was a collision with a light engine. The man admitted that he passed the signals at danger, but said his brake was defective and the rails were greasy. He admitted failing to sound his whistle at the junction. The jury found the charge not proven, and blamed the railway company for sending inexperienced men on the route.

THE Birmingham Corporation Tramway Committee have come to the conclusion, after making various experiments, that the watering of street curves on the tramway system is the most satisfactory method of overcoming the screeching difficulty. In order to reduce the expense the Committee have now decided to lay water connections from the mains to all the curves, the connections being so arranged as to allow a constant trickle of water to run in the groove of the rails. In this way it is hoped that the screeching noise will be done away with almost entirely.

THE London County Council have decided to give notice to the Metropolitan Electric Tramways Company, requiring it to sell to the Council, under the condition provided in the Tramways Act, 1870, that portion in London of the undertaking authorised by the Harrow-road and Paddington Tramways Act. The lines are situated in Harrow-road between a point near Kensal Green Cemetery, where the London and North-Western Railway crosses that thoroughfare, and the existing terminus at the Lock Bridge, near Amberley-road, and are worked on the overhead system of electric traction.

THE London, Tilbury and Southend Railway Company is making important improvements in Barking Junction Station, giving eight platforms, two more than the Great Eastern Company have at Stratford Station on their main line. The work, which was commenced late last spring, and is expected to be finished early in the new year, includes two new public bridges over all the various pairs of metals, from road to road, waiting-rooms, ticket offices, and the like, on most of the platforms, and other improvements, at the cost of some £150,000. The whole work is being carried out by the company, under the supervision of its own engineer.

LOCOMOTIVE smoke-prevention, says an American contemporary, has been demanded in so many cities of late, and is so desirable for the comfort of passengers that it was thoroughly discussed at the recent Chicago convention of the Travelling Engineers' Association. The unanimous sentiment was in favour of a brick arch for preventing smoke and protecting tubes. It was stated to assist materially in mixing the inflowing air with the gases of combustion, thus supplying oxygen and preventing the formation of smoke. The hot bricks also help to maintain proper combustion temperature when the engine is standing and gases are still coming from the coal.

FOR local journeys on the Prussian State railways in the neighbourhood of Mainz, some six-wheel coaches of the Berlin local service have been fitted up for accumulator traction. The average speed attained is 27 kms. to 36 kms./hour, the maximum 45 kms./hour. Each coach has six compartments with ten seats each. The battery consists of 180 cells of 200 ampère hours' capacity, each cell weighing 55 kilos. Two boxes together containing fifteen cells are placed under each seat, the battery compartment being made tight and ventilated. The complete battery, weighing 10,000 kilos., furnishes 68·5 kilowatt hours, so that the specific output is 7 watt-hours per kilo. of cell. The distance covered on one charge is 45-60 kms.

NOTES AND MEMORANDA.

THE Burmese Government propose to sell the lease of the Government rubber plantation at Mergui for a period of thirty years, with the right of renewal for another twenty years. The area contains about 340,000 rubber trees.

FOR cutting aluminium in a lathe, one of the best lubricants that can be used is said to be kerosene oil, as it prevents, to a great extent, the liability to tear the surface of the metal, and enables a better finish to be obtained.

AT the Roosevelt dam, being erected by the United States Reclamation Service in connection with the Salt River project, six gates weighing 20,000 lb. each will be used. The total maximum pressure to which the gates will be subjected is 80,000 lb.

THE Middlesbrough Town Council have adopted a scheme for the drainage of the west of the town by the construction of a sewer in two sections. One of these will be 3160 yards in length, costing £19,000, and the other will be 2232 yards long, costing £15,000.

THE German Government have decided to create a new naval port at Brunsbuttel, opposite Cuxhaven, in the mouth of the Elbe, and at the Western end of the Baltic Canal. The first step will be the construction of a dry dock at a cost of 1,500,000, which will be followed by the construction of other docks.

IT has been found that if two layers of pure water, one hot and the other cold, are separated by a membrane, a process of endosmosis takes place from the cold to the hot water, exactly comparable to that between water and sugar solution. The same phenomenon is shown in a very marked way when hot and cold air are separated by a paper membrane.

IT is reported that, after successful experiments and a demonstration of its practical utility, the Canadian Government have adopted the new marine fog signal invented by Mr. Thomas L. Wilson. The device, which is intended for use in connection with acetylene-lighted buoys and beacons, is automatic, being operated by explosion. The inventor affirms that it will run continuously and regularly for months without attention, and that it is absolutely independent of the action of waves.

AT the meeting of the Cardiff City Observatory Committee on November 30th it was announced that arrangements are busily proceeding for the installation of a seismograph at the observatory on Penylan Hill. The seismograph is being provided by the Cardiff Naturalists' Society, its upkeep being undertaken by the City Council. Professor Milne has urged the establishment of a seismograph at Cardiff, which will form a triangle with the existing stations at Birmingham and Shide.

AN incandescent mantle of pure ThO_2 is not luminous because it is transparent to almost all wave lengths. Addition of coloured CeO_2 increases the luminous effect up to 1 per cent. only; beyond this point the emission in the infra-red lowers the temperature of the mantle to such an extent as to diminish the luminous radiation. It was found that homogeneous mixtures of ThO_2 and CeO_2 could be prepared up to 7 per cent., but that a part of the cerium had lost its power to oxidise hydriodic acid. It is uncertain whether the limit of 7 per cent. CeO_2 represents a definite compound; in all probability it may be merely a solubility limit.

IN an article appearing in *Electrical Engineering*, Mr. H. M. Hobart deals with the year's progress in the design of electric generators for direct connection to steam turbines. He gives a number of illustrations, showing points of interest in both alternating and continuous-current machines for high speeds. Details of ventilating devices are discussed, and attention is directed to various means of securing the end connections of alternator stators. The improvements mentioned in the section dealing with continuous current are connected chiefly with commutator construction, brushes and brush holders, special windings and field connections.

PROFESSOR W. S. FRANKLIN and Mr. L. A. Freudenberger have published a description of an arrangement they have found satisfactory for measuring the resistance of electrolytes without the use of electrodes. The electrolyte is placed in an annular glass tank, which encircles the iron of a small transformer, the primary of which forms one arm of a resistance bridge. In the corresponding arm of the bridge a similar transformer is placed, and the resistance of its secondary is adjusted until the bridge is balanced, when an alternating current is supplied to it. The apparatus is said to be so simple, and the results are so good, that electrodeless methods should replace some of those at present in use.

DIRECT-ACTING steam pumps, says the *Iron and Coal Trades Review*, both single and duplex, are largely used in the mining fields of the States. They are extravagant in the consumption of fuel even under the best of conditions, and are liable to great additional losses from the use of leaky steam valves and pistons. Careful tests under favourable conditions, and the data obtained from actual practice, show the following consumption of steam or fuel per horse-power per hour:—Triplex power pumps require 1½ lb. to 5 lb. coal per horse-power per hour; small steam pumps, 25 lb.; large steam pumps, compounded, 13 lb.; pulsometer pumps, 60 lb. to 70 lb.; injectors and inspirators, 100 lb. per horse-power per hour.

IN determining the effects due to the resistance and capacity of cables in alternate-current working, two constants are of fundamental importance; the impedance of the cable when open-circuited, and its impedance when short-circuited. If these are known for a given length of cable, their values for any other length may be calculated. The calculation is in general complicated, but it has been shown that, within the limits likely to arise in practice, the amplitude of the short-circuit impedance is practically proportional, and the amplitude of the open-circuit impedance inversely proportional, to the length of cable; and that the changes in the phase angles of the impedances also follow fairly simple laws.

ACCORDING to an American contemporary, the peat briquetting plant of the Commercial Artificial Fuel Company, near Lambertville, Mich., has a capacity of 60 tons daily, the product containing 16·7 per cent. moisture, 55·3 volatile matter, 20·5 fixed carbon, and 7·5 ash. Its heating value is stated to be about 10,600 British thermal units per lb. The peat is obtained from a 10ft. bog by a dipper dredge, and taken in scows to the plant. Here it is first passed through a cutter, in which it is thoroughly disintegrated, and then through a kneading machine. It is next compressed and discharged through a die as 4in. by 4in. bars, which are cut by knives into briquettes 12in. long. The latter are then dried like soft brick in sheds.

A WRITER in the *Electric Journal* points out the necessity of adopting some consistent form of notation if slips are to be avoided in connection with problems relating to polyphase circuits. The diagram connections should in each case be drawn and lettered, and in dealing with the various electro-motive forces and currents the symbols by which these are denoted should be provided with suffixes to indicate the direction which is considered positive. Thus, if A B C denote the three corners of a Δ-circuit, E_{AB} would be taken to represent a voltage whose instantaneous value is considered positive if acting from A to B, and negative if acting from B to A, so that we should have $E_{AB} = -E_{BA}$. The usefulness of the notation is illustrated by a number of problems.

MISCELLANEA.

THE Board of Trade have intimated to the Heysham Council that they intend to revoke the Heysham Electric Lighting Order, 1904.

THE Bournemouth Corporation have decided to apply for powers to borrow over £8000 for widening the pier landing stage, and it is proposed to erect an electric lift on the West Cliff.

ACCORDING to the *Times of India* the sanitary condition of India is deplorable, the ignorance of hygiene is so abysmal, that, on purely sanitary lines, plague will probably continue in India for half a century.

FOUR Channel and Thames Estuary lightships are to be fitted with submarine signalling bells. With these, in foggy weather, they will be able to communicate with all passing ships on which receivers are fitted.

AT last Monday's meeting of the Tees Valley Water Board at Middlesbrough attention was drawn to a decrease of 4 million gallons in the water supplied to the district; it looked, the speaker said, as though the depression in the iron trade was beginning to affect them.

BRAZIL is preparing for the celebration next year of the hundredth anniversary of the opening of the port of that country to international commerce by a national exhibition of industrial, pastoral, and art products, to be held at Rio de Janeiro from June 15th to September 7th.

THE Bryncethin Colliery Company is at present having a large number of Coppée coke ovens, with recovery plant and Feldspar coal washeries, erected at its colliery. The outlay is estimated at about £70,000, and the work will probably be completed in about eighteen months.

THE Blyth Urban District Council have instructed a Newcastle firm of civil engineers to report fully on the water supply of the East and West wards of their district, including the quality and quantity of water from the several sources, as well as the existing reservoirs and filter beds.

A REPORT from America states that a fire broke out in the mines at Monongah, Virginia, last Sunday afternoon, and although it was quickly extinguished, it was thought advisable to abandon the rescue work for fear of another explosion. Fifty-three bodies were recovered on Sunday.

IT is reported that the American Smelting and Refining Company has started a new town near Trinidad, and contracted for the erection of eighty houses. It is further stated that every building in the town will be of concrete. The only wood to be used will be on the roofs and the inside fittings.

WE hear that steady progress is being made with the sinking of two shafts at Blairhall, Fife, for the Coltness Iron Company, Limited. Pumps have been put in to overcome the flow of water, 115 fathoms and 55 fathoms having already been sunk. It is expected that coal will be struck at a depth of 300 fathoms.

IT is reported that a new 200 horse-power six-cylinder Darracq car which has been especially built for speed purposes has undergone its preliminary test on the road. The new racer, which is said to have the most powerful engine ever put into a car, attained in three tests on the road in France the average speed of 125 miles an hour.

IT is reported that the construction of a novel type of vessel has just been arranged for by Japanese officials, the builders being Messrs. Vickers, Sons and Maxim. This vessel will be used for the transport to Japan of two submarines now under conttruction. In addition to this duty of transport, the ship is to be so designed that it can take the submarines into action.

IT is announced that the first regular station for the transmission of photographs by telegraph will be established at Munich on December 15th. A similar station is to be established in Berlin. London and Paris will later be connected with a service, so that the first commercial exchange of pictures by wire will shortly be in operation between these four cities.

IN a lecture given at a meeting of the Sheffield Society of Engineers on Tuesday evening, Professor Arnold, dealing with the question of testing structural steels, proposed to abandon the maximum stress as the base for the factor of safety, and to take the yield point as a datum line, deduct from this four tons, and on the remainder to use a factor of safety of at least 3 to 1.

THERE is a big decrease of tonnage launched on the Tyne since the beginning of the year as compared with the corresponding period of last year. The approximate amount of tonnage put into the water during the past eleven months is 178,249 tons, while in the corresponding period of 1906 the amount of tonnage launched was 213,378 tons, showing a decrease of 35,129 tons.

THE Manx Queen, a steamer that was a great favourite some years ago on the Isle of Man service, has been sold for breaking-up purposes. She was built on the Clyde in 1882 for the Boulogne and Folkestone service, and named the Duchess of Edinburgh. Three years later she was bought by the Barrow Steam Navigation Company, when she was re-nmaed with her present name.

THE Clyde Shipbuilding and Engineering Employers' Associations have intimated to all journeymen employed in the Clyde shipyards and engine and boiler shops that a reduction in wages will come into force with the New Year. The trades affected are ironworkers, boilermakers, engineers, shipwrights, woodworkers, joiners, &c. The reduction is 5 per cent. on piecework and 1s. a week on time rates.

ACCORDING to a contemporary, a Belgian military engineer, Commandant le Clement de Saint Marcq, has invented a new airship, which will be tried shortly. The inventor is a well-known authority on this subject, and while the plans on which the airship is built are withheld, it is said that almost a revolutionary departure has been made from all that has been created hitherto in the line of steerable balloons.

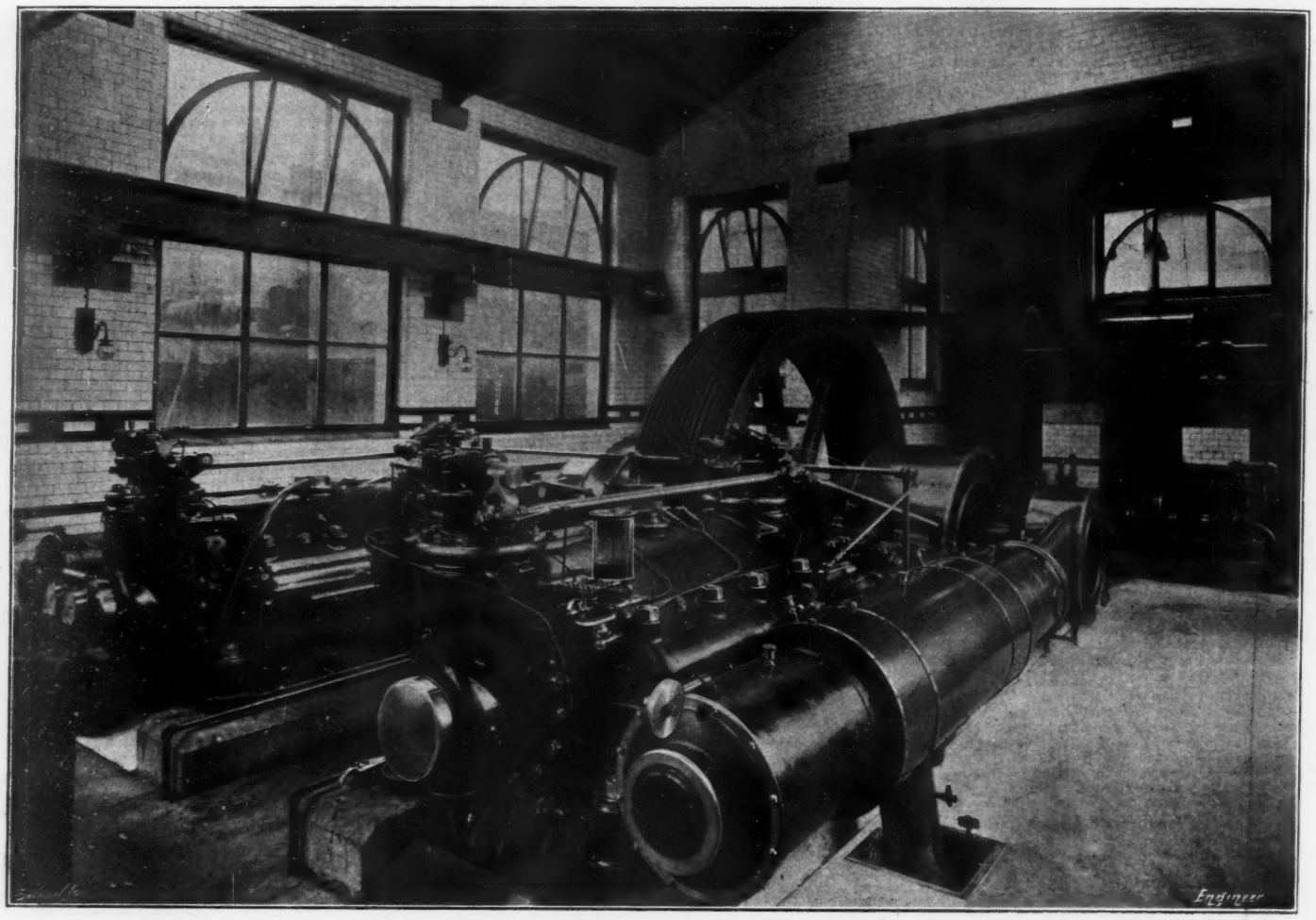
A FOUR-CYLINDER gas engine of 60 horse-power has been erected with great success on Ameise, one of the tugs on the Volga River, according to the *Zeitschrift für Maschinenbau*. The boat is 24 m. long by 3·65 m. beam, and 2·4 m. depth. On the trial trip the distance from Saratov to Astrachan, 1200 kiloms. (845 miles) was covered in fifty-two hours. Russian anthracite coal was burned. The gas engine, which also drove the dynamo for the electric lighting of the ship, worked very economically.

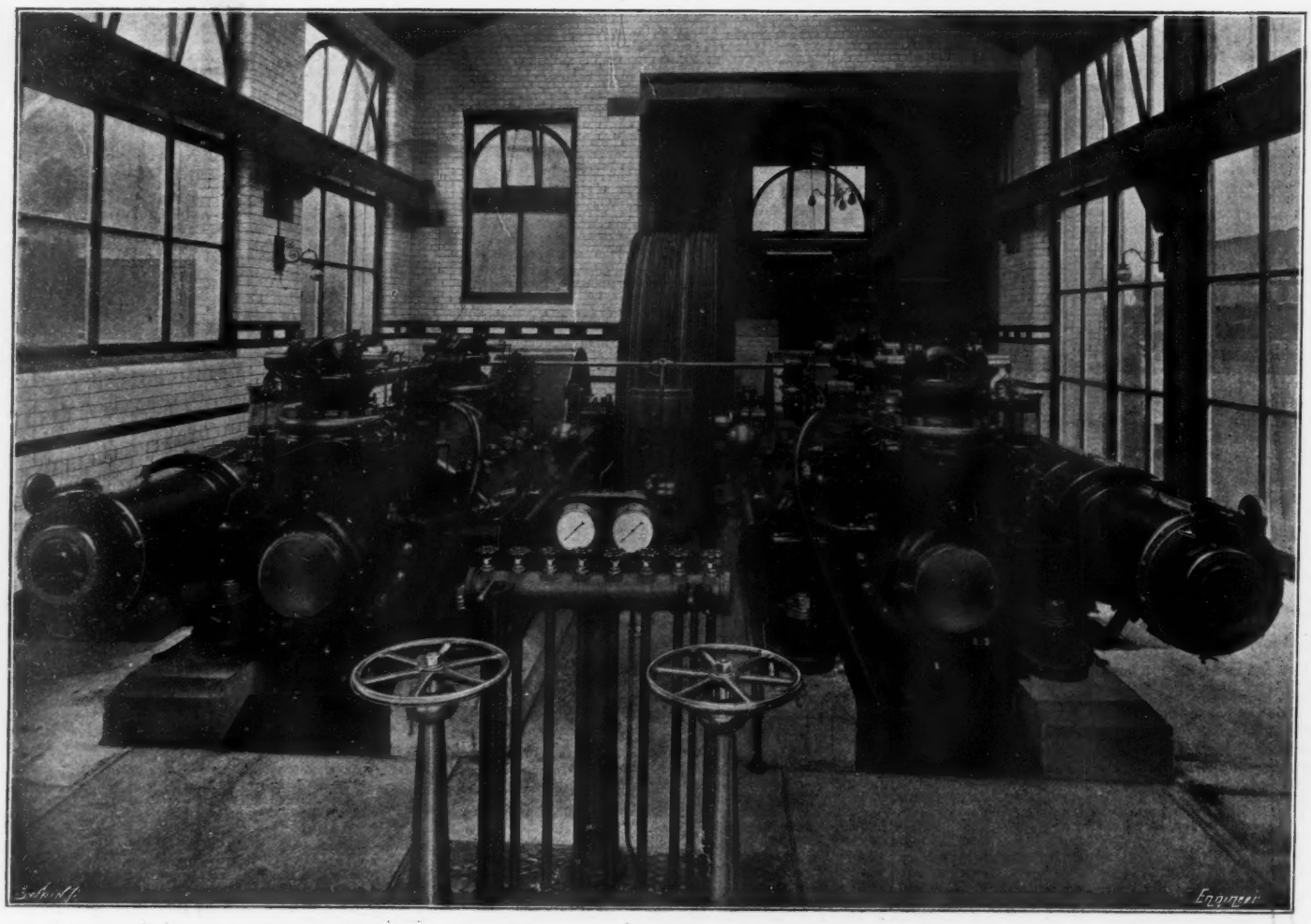
ACCORDING to the *Western Electrician*, the electrical equipment is to be a special feature on board the new American battleships Nos. 28 and 29, which are now being built. No. 29 will, besides, be the first American battleship to be propelled by turbines. Four 300-kilowatt Curtis turbo-generating sets will be erected on each ship to supply the lighting circuits and furnish power for about 100 motors, varying in size from 2 to 75 horse-power. These motors will be used to operate the turrets, ammunition hoists, cranes, winches, &c., to run the forced draught and the hull ventilation fans, and to supply power to the laundry and workshops.

GAS ENGINE IN A COTTON MILL

MATHER AND PLATT, LIMITED, MANCHESTER, ENGINEERS

(For description see page 655)





FOREIGN AGENTS FOR SALE OF THE ENGINEER.

AUSTRIA.—F. A. BROCKHAUS, *Seilergasse 4, Vienna.*
CHINA.—KELLY AND WALSH, LIMITED, *Shanghai and Hong Kong.*
EGYPT.—F. DIEMER, FINCK & BEYLAENDER, *Shepheard's-buildings, Cairo.*
FRANCE.—BOYVEAU & CHEVILLET, *Rue de la Banque, Paris.*
CHAPELOT & CIE., *Rue Dauphine, 30, Paris*
GERMANY.—ASHER AND CO., 5, *Unter den Linden, Berlin.*
F. A. BROCKHAUS, *Leipsic;* A. TWEITMEYER, *Leipsic.*
INDIA.—A. J. COMBRIDGE AND CO., *Railway Bookstalls, Bombay.*
ITALY.—LOESCHER AND CO., 307, *Corso, Rome;* BOCCA FRERES, *Turin;* ULRICO HOEPLI, *Milan.*
JAPAN.—KELLY AND WALSH, LIMITED, *Yokohama.*
Z. P. MARUYA AND CO., *Tokyo and Yokohama.*
RUSSIA.—C. RICKER, 14, *Nevsky Prospect, St. Petersburg.*
UNITED STATES OF AMERICA.—INTERNATIONAL NEWS CO., 83 *and* 85, *Duane-street, New York;* SUBSCRIPTION NEWS CO., *Chicago.*
S. AFRICA.—WM. DAWSON & SONS, LIMITED, 7, *Sea-st. (Box* 489), *Capetown.*
CENTRAL NEWS AGENCY, LIMITED, *Johannesburg, Capetown, Durban, &c., and at all their Bookstalls.*
J. C. JUTA AND CO., *Capetown, Port Elizabeth, Johannesburg, East London, Grahamstown.*
AUSTRALIA.—GORDON AND GOTCH, *Melbourne, Sydney, and Queen-street, Brisbane, &c.*
MELVILLE AND MULLEN, *Melbourne.*
TURNER AND HENDERSON, *Hunt-street, Sydney.*
NEW ZEALAND.—GORDON AND GOTCH, *Cuba-street Extension, Wellington, and Bedford-road, Christchurch.*
UPTON AND CO., *Auckland;* J. W., *Napier.*
CANADA.—MONTREAL NEWS CO., 386 *and* 388, *St. James-street, Montreal*
TORONTO NEWS CO., 42, *Yonge-street, Toronto.*
CEYLON.—WIJAYARTNA AND CO., *Colombo.*
JAMAICA.—SOLLES AND COCKING, *Kingston.*
STRAITS SETTLEMENTS.—KELLY AND WALSH, LIMITED, *Singapore.*

Subscriptions received at all the Post-offices on the Continent.

SUBSCRIPTIONS.

THE ENGINEER can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office on the following terms (paid in advance):—

Half-yearly (including double number) .. .. £0 14s. 6d.
Yearly (including two double numbers) .. .. £1 9s. 0d.

CLOTH READING CASES, to hold six issues, 2s. 6d. each, post free 2s. 10d.

If credit occur, an extra charge of two shillings and sixpence per annum will be made.

Foreign Subscriptions will, until further notice, be received at the rates given below. Foreign Subscribers paying in advance at these rates will receive THE ENGINEER weekly and post free. Subscriptions sent by Post-office Order must be made payable to THE ENGINEER, and accompanied by letter of advice to the Publisher.

THIN PAPER COPIES.		THICK PAPER COPIES.	
Half-yearly	£0 18s. 0d.	Half-yearly	£1 0s. 3d.
Yearly	£1 16s. 0d.	Yearly	£2 0s. 6d.

(The difference to cover extra postage)

ADVERTISEMENTS.

☞ The charge for advertisements of four lines and under is three shillings, for every two lines afterwards one shilling and sixpence; odd lines are charged one shilling. The line averages seven words. When an advertisement measures an inch or more, the charge is 10s. per inch. All single advertisements from the country must be accompanied by a Post-office Order in payment. Alternate advertisements will be inserted with all practical regularity, but regularity cannot be guaranteed in any such case. All except weekly advertisements are taken subject to this condition.

Advertisements cannot be inserted unless delivered before Five o'clock on Thursday evening, and in consequence of the necessity for going to press early with a portion of the edition ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

Telegraphic Address, "ENGINEER NEWSPAPER, LONDON." Telephone—No. 13352 Central.

PUBLISHER'S NOTICE.

*** *With this week's number is issued as a Supplement a two-page drawing of an Atlantic Type Locomotive, Great Indian Peninsular Railway. Every copy as issued by the Publisher includes a copy of this Supplement, and subscribers are requested to notify the fact should they not receive it.*

*** *If any subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the Paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

CONTENTS.

THE ENGINEER, 13th December, 1907.

	PAGE
THE ROYAL COMMISSION ON CANALS AND WATERWAYS. No. IX. (Ill.)	587
THE GERMAN INSTITUTION OF NAVAL ARCHITECTS. No. III.	588
LAND RECLAMATION IN HOLLAND	589
LOCOMOTIVE FOR THE GREAT INDIAN PENINSULAR RAILWAY. (Illus.)	590
THE FUTURE WATER SUPPLY OF LONDON. No. III.	591
THE SMITHFIELD SHOW. (Illustrated.)	592
OBITUARY	593
H.M.S. SWIFT	593
A MODERN QUARRY PLANT. (Illustrated.)	595
VICTORIAN RAILWAYS	596
DOCKYARD NOTES	596
RAILWAY MATTERS—NOTES AND MEMORANDA—MISCELLANEA	597
LEADING ARTICLES—The Vibration of Ships	599
The Quebec Bridge—The shipbuilding industry	600
Indian Railway Strikes—Naval Guns	601
LITERATURE	601
HYDRAULIC PIPE-BENDING MACHINE. (Illustrated.)	602
ADVICE TO YOUNG MOULDERS	602
ORE SEPARATION	602
A LARGE PLATFORM INDICATOR. (Illustrated.)	603
TRIALS OF THE TURBINE STEAMER CAMDEN	603
LETTERS TO THE EDITOR	604
600 HORSE-POWER TWO-CYCLE ENGINE. (Illustrated.)	605
MANCHESTER ASSOCIATION OF ENGINEERS	605
LABOUR-SAVING APPLIANCES AT THE MINES OF THE NEW KLEINFONTEIN COMPANY, TRANSVAAL. (Illustrated.)	606
THE INSTITUTION OF CIVIL ENGINEERS	607
AUTOMATIC SIGNALLING ON LOCOMOTIVES	608
MUSSOORIE HYDRO-ELECTRIC SCHEME	608
LETTERS FROM THE PROVINCES	609
NOTES FROM GERMANY	610
BRITISH PATENT SPECIFICATIONS. (Illustrated.)	611
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.)	612

TWO-PAGE SUPPLEMENT—ATLANTIC TYPE LOCOMOTIVE, GREAT INDIAN PENINSULAR RAILWAY.

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

W. L. A.—Write to C. A. Parsons and Co., Heaton Works, Newcastle-on-Tyne. If they cannot undertake it themselves they will direct you where to apply.

T. J. S.—To become a member of the Institution of Civil Engineers an examination has to be passed; of the Mechanicals, a certificate of a good mechanical engineering training, supported by members or associate members is required. Write to the secretaries of the respective Institutions for particulars.

G. D. S. (West Kensington).—Possibly the records produced by a telephone receiver might be read, but we fancy they would be extremely complicated and very long. Mr. Duddell has made the production of single notes visible, and his apparatus has been exhibited at various places. Why not take the wire of a telephone on a phonograph and obtain a sound record in that way?

H. E. A.—We fear you will find no book dealing with the cost of railway signalling, though it might be worth consulting Raynar Wilson's work on the subject. Generally, it may perhaps be taken that the first cost in this country is about £30 per lever. We do not know where you can find the detailed cost per mile of British railways, but the overall cost per mile, which is, of course, very variable, may be found in several places. Your best place to search would be in the "Proceedings" of the Civils. See also Acworth's "Railways of England" and "Elements of Railway Economics," and Ross's "British Railways."

MEETINGS NEXT WEEK.

INSTITUTION OF ELECTRICAL ENGINEERS: LEEDS LOCAL SECTION.—Thursday, December 19th, at the University, Leeds. General meeting. Paper, "The Commercial Aspects of Electric Power Supply," by Mr. W. A. Woodhouse.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 19th, at 8 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Ordinary general meeting. Paper, "Electrical Power in Railway Goods Warehouses," by H. Henderson.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, December 18th, at 8 p.m., at the Royal Institution, Colquitt-street, Liverpool. Ordinary meeting. Paper, "The Gorpley Works for the Supply of Water to Todmorden," by Mr John H. Parkin, Assoc. M. Inst. C.E.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 20th, at 8 p.m., in the Institution House, Storey's Gate, St. James's Park, S.W. Ordinary general meeting. Paper, "Notes on the Manufacture and Upkeep of Willing Quarters," by Dr. H. T. Ashton, of the Royal Small Arms Factory, Enfield Lock.

ROYAL METEOROLOGICAL SOCIETY. Wednesday, December 18th, at 7.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Ordinary meeting. Papers: "The Possibility of a Topography of the Air based on Balloon Observations with special Theodolites," by Capt. C. H. Ley, F.R. Met. Soc. "Indications of Approaching Frost," by Richard Strachan, F.R. Met. Soc.

SOCIETY OF ARTS.—Monday, December 16th, at 8 p.m., at John-street, Adelphi, London, W.C. Cantor Lectures: "The Theory of the Microscope," by Conrad Beck, F.R.M.S. Tuesday, December 17th, at 8 p.m. Applied Art Section. "How to Make the Most of a Museum" by Lewis Foreman Day, F.S.A. Wednesday, December 18th, at 8 p.m. Ordinary meeting. "Le Rôle de la France en Afrique Occidental," by Monsieur Lucien Hubert, Député des Ardennes. The author will read his paper in French.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 17th, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Papers: "Keyham Dockyard Extension," by Sir Whately Eliot, M. Inst. C.E. "Keyham Dockyard Extension, Temporary Works, and Plant and Appliances used in Construction," by George Hall Scott, M. Inst. C.E. Friday, December 20th, at 8 p.m. Students' meeting. Paper, "The Mechanical and Thermal Efficiency of a Petrol Engine," by L. G. E. Morse, Stud. Inst. C.E.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 14th, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. General meeting. Paper for discussion: "Improvements required in Inland Navigation," by Mr. Henry Rudolph de Salis. "A Bye product Coking Plant at Clay Cross," by Mr. W. B. M. Jackson. "Notes on Bye-product Coke Ovens, with Special Reference to the Koppers Oven," by Mr. A. Victor Kochs. Papers: "On a Deficiency in the Nomenclature of Mineral Deposits," by Prof. Henry Louis. "Notes on Mining and Engineering in America and Canada," by Mr. Walter Rowley.

DEATHS.

On the 7th December, at 33, Montpellier-crescent, Brighton, GEORGE LOWE REID, M. Inst. C.E., in his 79th year.

On the 9th December, at his residence, 97, London-road, Leicester, GEORGE JESSOP, A.M. Inst. C.E., aged 55 years.

On the 7th inst., at Bellfield, Dumbarton, EDWIN GRIFFITH, M. Inst. C.E., of the firm of Denny and Co., Engineers, Dumbarton.

On the 10th December, at Burwell, WILLIAM GORNSBY, of Burwell Park, Louth, and Elsham House, Grantham, in his 70th year.

THE ENGINEER.

DECEMBER 13, 1907.

The Vibration of Ships.

IN the vibration of steamships the fact that the frequent regular repetition of relatively minute forces may generate enormous effects is made manifest. The unbalanced weights in a reciprocating engine are but a tiny fraction of the whole displacement of a ship, and yet they can, by their persistence, throw the great structure into a state of tremor, and may, with but little augmentation, actually endanger its integrity. The parallel with the historical example of a suspension bridge being set oscillating and ultimately destroyed by the well-timed impacts of a pellet from a pea-shooter is obvious. It is the succession of blows, minute and powerless as individuals, but mighty when applied in succession, and timed to synchronise with the natural period of oscillation of the structure, that sets up the disagreeable and dangerous vibration of ships. The fact is, of course, universally known, but like other recognised facts it has been, or appears to have been, if not forgotten, at least treated with less consideration than it demands.

It was presumed that when the turbine took the place of the reciprocating engine, ship vibration would cease. The very existence of the turbine depended upon its perfect balance, and vibration in it was, therefore, out of the question. Hence, the power assumed to be at the root of the evil being removed, the evil itself would disappear. The falsity of this argument was probably proclaimed to deaf ears by a score of ships, which in spite of all that science could do to balance their engines still vibrated, but shipbuilders, possessed with the idea that the engine was the sole, as it is no doubt the principal, cause of the trouble, concentrated their attention on it alone. The turbine has shown us their mistake. Engine vibration has indeed ceased, but there is not a single turbine ship running which does not suffer at one speed or another from vibration produced by some other cause or causes. It is not so great in amplitude as that of reciprocating ships, but it is none the less a defect which defies the naval architect and engineer. In the Mauretania it is so marked that a special correspondent of the *Times* has asserted that at 25 knots it is difficult either to read or write, save on the lower decks. The tremor is of a peculiar order, and during a trip on the same vessel we found that it followed a cycle, which may be described as beginning with a two seconds pause, succeeded by a wave of vibration, which augments gradually for some five to seven seconds, and then dies wholly away in the same time. The amplitude was, at 24 knots, very small, and the movement disappeared altogether at slower speeds, but at a higher velocity it is apparently—we speak without direct experience—even more marked. No disgrace attaches to the builders or designers for the existence of this state of affairs; the Mauretania vibrates probably less than any other vessel of her speed in the world; but, on the other hand, that a ship on which the highest scientific and engineering skill has been expended should be still subject to a defect of the kind is a reflection on our state of knowledge which every effort must be made to remove. The cause, no doubt, is to be found outside the vessel; and whilst we shall not go so far as to say that the mere friction of water over a comparatively rough surface cannot set up vibrations as a rosined glove does in musical canes, yet the propellers, as the only moving things outside the hull, must be held principally responsible. But even if we admit that the propellers are at the root of the matter, we are still far from a solution of the problem. If it lay merely in a lack of balance of the blades, the difficulty could and would be readily overcome. Propellers, even for a large ship, may be corrected in this respect to a nicety, but still the vibration remains. Possibly, if the adjustment were made with the blades submerged to their full depth in sea water a difference from the balance in air might be discovered. It is conceivable that the density of the blades, or even of parts of the boss, which at high speeds is an important detail, is not the same at all parts, and it is possible that when submerged a lack of balance results. We can see that in a four-bladed propeller, for example, a blade with a large hollow in it might be balanced by one of denser and thinner material on the opposite side, and yet such a propeller would, under water, be thrown out of balance by the different displacements of the blades. Only a close mathematical inquiry could say what effect such differences in volume and density as are likely to exist could have. Another cause of trouble may possibly be found in errors of pitch and spacing of the blades. Propellers are not invariably made with the precision of machine work; the blades are cast and attached to the boss, but care is not always taken that they are spaced absolutely equal, and that the axis of each is truly radial. Propellers are designed to produce the maximum thrust, and the vibration that they may cause has, too often, been left to chance. It is time that a set of blades was made for a big ship with as much accuracy as the engines themselves, and machined in every part. Instructive results would ensue. We are aware that machined propellers have been tried, but we believe only on a small scale and with doubtful results. The cost has generally precluded their use. We do not assert by any means that machining the blades would cure the trouble; for other causes than irregularities of construction are at work. It is held, for example, that the down-going blades as they move from water less to water more dense, and from regions of less to regions of greater pressure, meet with increasing resistance. If this is indeed a fruitful source of vibration, a cure in any single propeller must be looked for in vain; the conditions are beyond the power of man to change. But whilst we cannot, if that is the case,

do anything for one propeller, we may effect an improvement by dealing with a group. For example, the synchronisations of two propellers are likely to cause rhythmical impulses which may be reduced by slight changes in one or the other, or even by such a large change as the employment of a four-bladed screw on one side of a ship and a three-bladed on the other; then, again, the race from a forward propeller may act upon the propeller behind it and set up vibration, and the propinquity of propellers to the hull and their direction of rotation may have effects.

All these points demand careful examination. They are known and talked about by marine engineers, but the fact that the latest and best of our ships are not free from propeller vibrations is evidence sufficient that the subject requires fuller and more exhaustive examination. And since, as we have said in our opening paragraph, the enormous results are produced by very small causes, the conquest of the difficulty can only be effected by thorough-going scientific investigation carried out with the care and precision of laboratory experiments. It might be found that the absolute reduction of vibration was an excessively costly process, but to have absolutely definite knowledge of the causes producing it would give us the means of attacking it, and in the course of time the difficulties would be overcome. It remains only to say that we have not in these few notes attempted to deal with the comparatively brutal plan of adding useless weight and strength to the structure in order to mask or kill the effects. That is evading, not overcoming the difficulty.

The Quebec Bridge.

Although the report of the Commission appointed to inquire into the circumstances of the failure of the Quebec Bridge has not yet been made public, the truth is being brought to light almost day by day. The *Engineering News* for November 28th has devoted many pages to the reproduction of the evidence given by various influential witnesses. We shall not follow the example set by our contemporary, who has not hesitated to award blame without waiting for the verdict of the Commissioners. But facts of an extremely instructive character have been made available; and we are now in a position to understand why the bridge fell down. Put in a nutshell, the truth is that the design was one which could not be carried out with success. No one seems at first to have been aware of this, least of all those who were in the drawing-offices. It was not until the design reached the shops and the foremen had been taken into consultation that the truth came out, and we find that as a consequence various expedients had to be adopted in the shape of changes and alterations made in order to render the bare construction of the bridge possible.

We have before us the evidence of Mr. David Reeves, president of the Phœnix Bridge Company. The whole trend of his evidence is to throw the responsibility for the design on the shoulders of Mr. Cooper—who, we may say incidentally, was paid a fee as consulting engineer which barely reimbursed him for his office expenses alone. Mr. Reeves is emphatic as to the precautions taken to secure excellence all round. "The erection of this bridge was," he says, "an important undertaking, and every precaution was taken to avoid unnecessary risks, and our whole organisation was impressed with this idea." Unconsciously he bears testimony to the incompetence of his staff. "When the compression chord members began to yield at several places one after another, as we can now see, and the whole bridge was on the verge of collapse, as afterwards developed, our staff at the bridge site observed the signs, and acted promptly and efficiently. They calculated correctly the stresses on the several members, and decided that failure from such stresses was impossible." We commend to Mr. Reeves' attention a well-known story about a man in the stocks and a legal gentleman who conversed with him. Mr. Reeves told the Commission that his company had no reason for wishing to economise in material, as it was paid by the pound and not by a lump sum. He asserts that the cause of failure must remain unknown; that the catastrophe was fortuitous and its occurrence contrary to all probabilities—an utterance equally ingenious and unconvincing.

Then we have the far more important and interesting evidence of Mr. Frank P. Norris, the manager of the Phœnix Bridge Company. As far back as the spring of 1900 he was told that it was possible that instructions would be soon given him to proceed with the construction of this part of the bridge. Then the troubles began. No pin bridge of the same dimensions or anything near them had ever been made. In the drawing-office a pin and an eye were just a pin and an eye, and one size was as easily drawn and calculated as another. But the case in the works was entirely different. A division of opinion existed as to how the link bars and eyes were to be made. It was ruled that no bars over 2in. thick could be made of sufficient excellence to pass the tests. The links were to be 15in. wide by 2in. thick. How were these to be provided with eyes for pins from 12in. to 14in. diameter? One scheme proposed the cutting of the bars out of plates; but, says Mr. Norris, "it would have been next to impossible, owing to the immense size of the bars, to get plates large enough, some of the bars requiring eyes 35½in. diameter, and the bar measuring 85ft. in length, which would have required a plate 36in. by 2in. by 85ft. 6in., weighing 20,948 lb., which no mill in the world could roll." Therefore Mr. Norris made an estimate of the cost of upsetting and forging these eye-bars from a 15in. by 2in. bar. He then spent £200 in altering an upsetting machine, made a few eye bars experimentally, and was satisfied with the results. The plant in the works was then augmented and strengthened, at a cost of about 250,000 dols. When they came to the pins, he found that he could buy nothing of sufficient quality, and he had to pay 20 dols. a ton extra to the Bethlehem Steel Company for forging the pins. Again, when he came to test the shackles supplied for use with the big traveller—"shackles made by the best makers in the country"—they were found untrustworthy, and he had to forge the shackles also. "We all appreciated the great importance of getting the best pin material obtainable, as they had an enormous load to carry, and after many weeks of careful consideration of this particular part of the structure we were instructed to order these pins at this large additional cost, by Mr. David Reeves, president, who from the very beginning said that we must use the best of everything in this bridge, regardless of cost. These instructions have been rigidly lived up to." The evidence given by Mr. Ellsworth L. Edwards, chief shop inspector, confirms the view, that while the unit stresses allowed were so high that the most minute accuracy was necessary in the fitting of the parts, that accuracy could be obtained only with difficulty. Thus, he told the Commission that "from actual measurements we know that the accuracy of the milling done by the rotary planer for the larger members of the Quebec Bridge varied from a true plane, where such variation occurred, from $\frac{1}{64}$in. to $\frac{1}{32}$in. This was the best the machine could do."

The engineer to the Phœnix Bridge Company, Mr. Szlapka, put in an exceedingly interesting account of the method adopted in designing the bridge. It would serve no useful purpose to make any extracts from this. Once more we have evidence that the parts of the bridge were so unwieldy that great difficulty was incurred in handling them. The railway authorities had to make special arrangements, which do not appear to have been invariably satisfactory. The most important fact, however, which came out is that the shore span which failed was actually made before the details of the rest of the structure had been decided upon, with the result that high as the unit stresses were to begin with, they were augmented. This seems to have been due to an increase in the length of the central span. The weights of the suspended span, and of the cantilever arm assumed in the first calculation of the stresses of the anchor arm, were smaller than the weights as finally obtained. Consequently, the stresses of the anchor arm, due to these increased weights, were increased, the anchor arm having been built in the meantime. The witness explained that this could not be avoided, because there was not sufficient time available. If the bridge had been successfully completed the stresses in the anchor arm would have been 21,200 lb., or nearly 9·5 tons per square inch.

Under ordinary conditions the members of a bridge or any similar structure will, when stressed, help each other, the factor of safety coming into play. Thus let us suppose that half a dozen bars pull on a pin threaded through eyes at the end, and that one of these bars does not for some reason carry its full share of the load. The other five bars will take it, because they have strength enough and to spare. But if all the six bars are loaded near their limit, then the failure of one to take its share may lead to the collapse of the whole structure. This is the reason why such extraordinary accuracy of workmanship was necessary, and mistakes became of an importance that they would not have possessed had the factor of safety been larger. The attempt was made, indeed, to render small factors admissible by the use of minute accuracy of fitting and great care in the proportioning of all the parts to the work they had each to do; but the magnitude of the parts and the enormous absolute stresses they had to carry rendered mathematical accuracy unattainable. The lesson taught is, in the first place, that only under very special conditions, when 4 to 1 may be tolerated, is a reduction in the factor of safety below 5 to 1 permissible. The second lesson is, that the use of unwieldy single members is not good practice. The idea is very attractive, particularly on paper. But the facilities which exist for transport and erection must always be taken into account. There are other deductions which will, no doubt, be drawn. In justice to all concerned, however, it is but fair to suspend judgment. That to be sound must come from those who are in possession of all the evidence—that is to say, the members of the Commission. The apportioning of the blame just now can only be classed with other guesses at truth.

The Shipbuilding Industry.

The period of prosperity which the shipbuilding industry enjoyed in 1905 and 1906, and during the first half of the current year, has now been succeeded by a term of depression, the present symptoms of which, it is to be hoped, will represent the final stage of the downward movement. As will be remembered, the output of new construction in those years was greater than in any preceding year, and the workmen participated in the general improvement of employment at the shipyards. The situation of affairs has, however, undergone a change since the first half of this year passed away. After allowing for all variations in regard to sales to foreign and colonial owners in 1906, purchases from foreign and colonial proprietors, and vessels lost at sea or broken up, there was a net increase of 764,000 tons in the mercantile marine of the United Kingdom in that year. This augmentation, which constituted a record, and to which has to be added the tonnage of ships placed under the British flag in 1905, represents a very considerable expansion in the vessels in the possession of our shipowners, apart from the increase made during 1907. These developments suggest that, if over-production has not been brought about for a time, the output of new construction has at all events been adequate for the purpose of meeting the demands of shipowners and assisting in imparting a temporary check to the placing of new orders. Other matters which come into consideration are the financial stringency in different parts of the world, the high price of new ships, owing to the dearness of coal and of shipbuilding material, and the labour unrest and declarations of policy by so-called labour leaders during the past year and announced for the near future. In fact, the labour agitation in various trades is in itself a serious source of danger, inasmuch as it deters capitalists from embarking upon new undertakings, including shipping, and consequently the shipbuilding industry indirectly. Even confidence in the recent settlement of the railway labour problem, which threatened to disorganise every other trade in the country for a short time, will now be somewhat rudely shaken by the intimation made on behalf of the railway servants that there will be nothing to prevent them striking against the decisions of arbitration boards if it is deemed necessary to do so. This announcement will tend to throw a shadow over new enterprises in general, and will certainly not assist the shipping and shipbuilding trades.

The depression in the shipbuilding industry, which has been already manifested by the gradual clearance of vessels from the stocks at some of the yards on the Clyde and the North-East Coast, has naturally had an unfavourable reaction on the iron and steel trade, which depends upon the former for the disposal of a large portion of the production that goes into consumption in the inland market. Various blast furnaces have already been shut down in West Cumberland and on the North-East Coast, and steel works and rolling mills have been temporarily closed in Scotland and in the south of Durham, and other works will probably be brought to a standstill unless a decided change for the better takes place in the near future. It will, of course, be necessary to reduce prices of shipbuilding material, but opinions, when judged from the standpoint of the maker or from that of the shipbuilder, differ as to what the rate should be. In this connection it was mentioned at a recent meeting of a well-known steel company that if the prices realised in the past year had been equal to those prevailing in the United States the company would have earned profits greater by £500,000 than those recorded in the accounts. The result, it was added, would have been serious and irreparable injury to the shipbuilding interests of the United Kingdom, and this was put forward without any desire to introduce the question of Protection or Free Trade. The inference to be drawn from this

statement is that moderation has been observed in prices during the past twelve months. But the principal of a shipbuilding firm on the North-East Coast, in referring generally to steel prices after having witnessed the launch of the last vessel remaining on the company's stocks, has just put the question in an entirely different light. He declared that British producers have for some time past been supplying foreign builders with material at as much as 15s. per ton less than they charged English builders, and that whilst the shipyards in Norway, Sweden, and Germany are full of work, the British shipyard workers are starving. We disclaim any responsibility for the amount of the stated difference between home and export quotations, but that large quantities of material have been disposed of at low prices to foreign yards in the present year is shown by the fact that the German plate rolling mill owners have loudly complained of the severe competition of British rivals in the matter of cheap prices. The import figures for Germany confirm a large increase in the purchases of ship plates, but the augmentation is only about one-third of the total expansion in the British plate exports this year, and the quantitative difference has probably gone also at low prices to shipbuilders in Norway and Sweden, as previously suggested.

The future outlook for the shipbuilding industry is far from promising at the present time, and no indications exist that any improvement will take place early next year. Orders for new ships are exceedingly scarce, and for those which are offered the prices would be unremunerative. It is, therefore, to be feared that unless steel makers reduce prices for shipbuilding material there will be little inducement for the conclusion of fresh business in this direction, whilst in the absence of a market for the diversion of this particular output, the closing of further works which largely depend upon the custom of the shipbuilding trade must be expected. But assistance to builders in respect of prices will probably soon be rendered by the operation of stronger German competition than has been experienced for some time past. Although the German steel makers have on hand stupendous orders for permanent way material for the next three years, and considerable contracts have been arranged with the locomotive and wagon works, there is still a large amount of steel available for other purposes, quite apart from the development of the navy and the mercantile marine. If this were not the case the anomalous position would not in the inland market have prevailed, as it did until a few days ago, of basic steel bars being actually offered at cheaper rates than the billets themselves. But the prices of semi-finished steel and of shapes have just been reduced by 10s. per ton in each case, and as the low export prices have not brought about the desired amount of business, still cheaper quotations are to be made for this purpose. In the circumstances it is probable that the promotion of the export of Teutonic semi-manufactured steel and of shapes by the Steel Syndicate, and of other products by the constituents of the Syndicate in their individual capacity, will tend to produce a fall in the prices of shipbuilding material in the United Kingdom. The Steel Syndicate is strong in itself, but it is helpless in regard to one half or 6,000,000 tons of the total output in that country. It is, however, a debatable question whether lower prices and the lower wages which were discussed at a meeting of the Shipbuilders' Federation and the Boilermakers' Society at Newcastle on Wednesday, will have the effect of retarding the downward stage upon which the shipbuilding industry has embarked.

Indian Railway Strikes.

IN our last issue utterance was given to a first note of warning against the fallacy of regarding dereliction of duty amongst the staff on Indian railways from the same point of view as a similar offence in this country. To attach undue importance to the movement by rushing to the conclusion that a permanent council of arbitration is inevitable is but to encourage the spirit of revolt, and the proposal to create clumsy and unwieldy conciliatory machinery which, once established, can only justify its existence by being continually kept in motion, is to invite discontent, to induce artificial grievances, and to keep open a sore which should yield to treatment by the straightforward operation of, in the first instance, cutting out the canker of insubordination by suppressing indiscipline with a strong hand, and then meeting by sympathetic recognition the title to better terms reasonably claimed.

It now remains to pass under review the circumstances which have, so far, stood in the way of railway administrations in dealing with this problem, which inquiry may serve to explain the delay in arriving at a satisfactory solution. The validity of the represented grievances once admitted—wholly, or even partially—the responsibility for failing to impress on the home boards of directors the danger of procrastination in meeting reasonable demands must rest primarily with the agents, but there is this much to be said in extenuation—the development of business on some of the lines in India has of late years been characterised by such an unexpectedly rapid and vigorous growth that both the funds and the time at the disposal of managements have proved unequal to the occasion. With the first freshet of a sudden, unanticipated flood, immediate instincts of self-protection usually point to damming rather than guiding the superabundance of waters, and if, in their endeavour to meet the rush, Indian railway administrations have found themselves compelled to postpone consideration of a multitude of claims arising out of this increase, it must be borne in mind that it has taken time to realise that the increase has come as a permanency, and that it has by no means as yet reached high-water mark. Harassed by Chambers of Commerce clamouring for more wagons, by traffic superintendents urging higher capacity stock, by locomotive superintendents calling for more powerful engines, by engineers pointing in despair to their weak girders and light permanent way, by the Post-office postulating for faster train service, and by the stupid native Press importunately demanding as a political right equality with English practice in the matter of third-class carriage upholstery—overwhelmed by these and a hundred other sudden calls on their attention, is it surprising that agents should have temporarily disregarded the claims of the working staff to an increase in emoluments in reward for increased trouble and responsibility, and that such representations should, under the circumstances, not have met with that sympathetic treatment they undoubtedly deserve? Such, briefly, is the position. The officers themselves are underpaid, considering their enhanced responsibilities, and if the subordinates have shown a little less patience than have their officers in the struggle to share in the general prosperity, such an issue is only what might be expected. This precipitancy is much to be deplored for the bad blood it has engendered and the injury it has done to discipline, but seeing that the question has now come prominently forward, it must attract the early attention of railway directors.

The whole question of railway reform in India is one of ways and means. Extensions and improvements have become such matters of urgency that funds on a liberal scale are now required if progress is to be made. Neither the raising of capital nor the allotment of funds from the general revenues of the country seem, under the existing system of Imperial finance, to be any longer able to cope with the demand, and Mr. Morley's efforts to find a *modus vivendi*—in search of which a committee of experts are now engaged in recording evidence—will, it is sincerely to be hoped, be crowned with success. There seems to be little doubt that money will be forthcoming if enterprise be suitably guaranteed by the Secretary of State for India.

Naval Guns.

IN satisfying a laudable desire to have the best, we do not infrequently miss the fitness of a thing for a particular purpose. The man who made packing-cases of polished figured walnut was very obviously wasting a valuable material on a duty which could equally well have been performed by something cheaper. Glaring cases like that do not often present themselves, but we might find fairly close parallels without much exertion. The lack of fitness is, however, as a rule, less patent and more likely to escape detection. An interesting example which is exercising the minds of the more thoughtful naval officers may be found in the armament of torpedo boat destroyers. Most of these vessels are armed with long twelve-pounders, whilst the latest and largest carry 4in. pieces precisely similar to the weapons carried by cruisers or battleships, and it is being asked if such guns are really the most suitable armament for these vessels? It is pointed out that the destroyer is not intended to engage in long-range practice with cruisers or battleships, from which it should keep its distance; it is, on the other hand, expected to fight vessels of its own class at comparatively short range, and it is becoming every day more certain that a 3in. shell is not large enough to stop vessels of such size as the new destroyers. Would it not then be better to reduce the length and weight of the present guns at the sacrifice of unnecessary muzzle-velocity, and put the weight gained into bigger bore? There is, clearly, much to be said on both sides of the question. The advantages of uniformity must be sacrificed if a special gun is got out for destroyers, and bigger bore means generally bulkier and heavier ammunition, which involves, if the number of rounds is not to be reduced, larger ammunition rooms and more weight to be carried. It is further contended that great range is valuable, at least in emergency, and ought not to be sacrificed. With such conflicting elements on both sides it is difficult to form a definite opinion, but many naval officers of experience are firm in the opinion that a 4in. gun is required, and that by the adoption of a special design of reduced length, weight, and range, torpedo boat destroyers might be better armed than they are at present.

LITERATURE.

General Foundry Practice. By ANDREW MCWILLIAM, A.R.S.M., Assistant Professor of Metallurgy, Sheffield University, and PERCY LONGMUIR, Carnegie Medalist, Consulting Metallurgist, some time Foundry Foreman. Messrs. Charles Griffin and Co., Limited.

FOUNDRY practice is a branch of technology about which comparatively little has been published in England, and this text-book fills a gap in metallurgical literature which has long been needed. The book is intended as a handbook for master founders apprentices and others connected with foundry practice, but will also be found very useful by engineers and all technical men interested directly or indirectly in the casting of metals. Moulding in all its details is very completely dealt with and explained in a clear, concise manner, illustrated by excellent sketches. The difficult subject of chill castings is exceptionally well described in a chapter, with which, the only fault we have to find is, that it is too short. The practical moulder will find many useful hints, and to the apprentice who is learning his trade the first portion of the book should be very valuable, and a careful study of it cannot fail to give him an intelligent grasp of the principles which underlie the various operations he has to perform. The chapter on cast iron we think would have been quite as well without the illustrations of pig iron fractures, as this is one of the things which cannot be taught by illustration, however good; the *actual* fractures of different grades of pig iron must be examined carefully to get anything like an intimate acquaintance with them.

In the chapter on furnaces it seems to us a mistake that a sketch of the Thwaite furnace with regenerators on top, erected many years ago at the Sheffield Technical School, should have been given as an illustration of the open hearth furnace, as although it is capable, no doubt, of doing good work, it is a type which has never been erected elsewhere, and the selection of it is liable to be misleading to a student who has had no steel works experience. Although differences in practice in moulding for steel and cast iron are referred to in various parts of the book, and there is a chapter on the different steel processes in use, we should like to have seen a separate chapter devoted entirely to the steel foundry, and we hope in another edition the authors may see their way to give this. Taken altogether the book is an excellent one, written by men with a practical acquaintance with the subject, and we strongly recommend it to all interested in foundry work.

SHORT NOTICES.

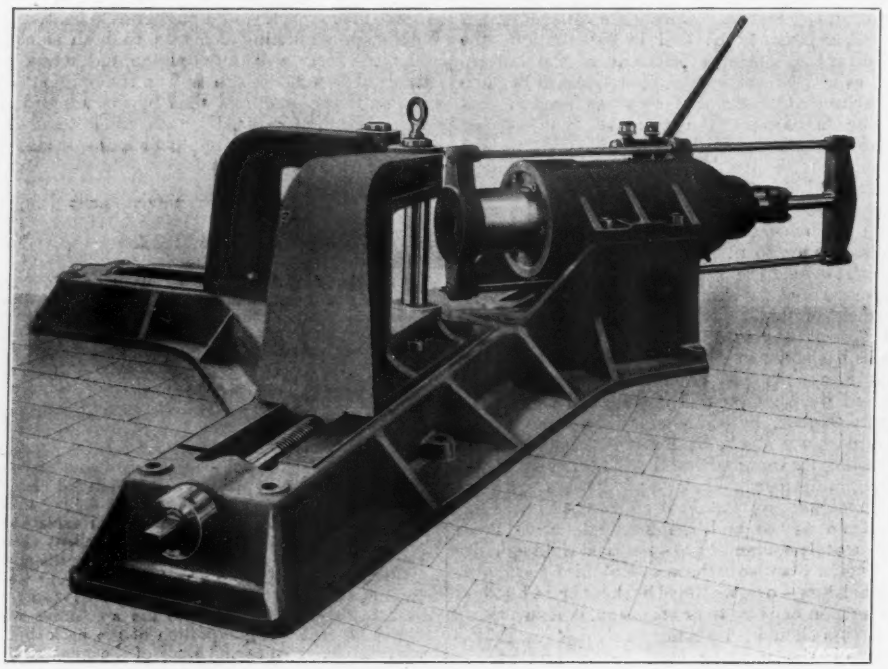
The Design and Construction of Dams. By Edward Wegmann, M. Am. Soc. C.E. Fifth edition. London: Chapman and Hall, Limited. Price 21s. net.—The popularity and value of this book can be gauged from the fact that it is now in its fifth edition. It is a work of much practical value, and as such has been deservedly appreciated by engineers not only in America but also in this country. The book is an exhaustive treatise on the design and construction of dams, which includes masonry, earth, rock-fill, timber and steel structures, and also the principal types of movable dams. The chapter on the construction of masonry dams has been entirely re-written, and the newest theories proposed for obtaining the necessary calculations have been included. Among the new matter added to the book are descriptions of steel, and steel and concrete dams, high earth dams, Stoney sluice gates, and rolling dams. Descriptions are given of most of the important structures built or in the course of construction; and there are many excellent illustrations and drawings accompanying the letterpress. At the end of the book the author gives no less than 100 really excellent plates showing the profile of well-known dams, and also many nicely executed drawings on India paper.

The Engineering Index Annual. 1906. *The Engineering Magazine*, Kean-street, Aldwych. 10s. cloth; 12s. 6d. half-calf.—This book is a continuation of the work originally started by the late Professor J. B. Johnson. It is intended as a guide to the vast mass of information in the numerous engineering publications. Four editions have previously been published, each covering with increasing fulness the field of engineering periodical literature. Two hundred and fifty technical and engineering journals in six different languages are indexed, about one-fourth of the periodicals being in foreign languages. A brief abstract is given in every case, showing the nature of the article indexed. This last volume enables the investigator to trace a vast amount of valuable information which has been published from time to time down to the close of the year 1906. The volume is classified under a number of different branches of engineering.

"*The Practical Engineer*" *Pocket-book and Diary*, 1908. London: The Technical Publishing Co., Limited, 55 and 56, Chancery-lane, W.C. Price 1s. net.—A considerable amount of fresh matter is included in this new issue which should make the book more useful even than its predecessor. The book has also been revised and a few more pages have been added. The new information which is now included has reference to ball and roller bearings, boilers and steam motor vehicles, cranes, reinforced concrete, superheated steam, tests on steam turbines, tractive resistance on roads, strength of rings, concrete piles, cooling towers, &c. There is also a new table of piston constants.

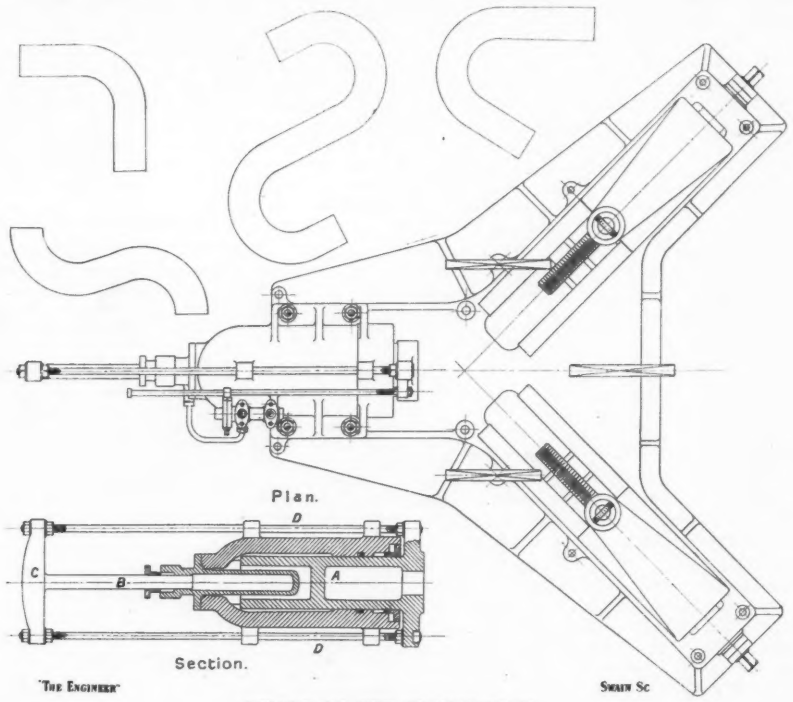
HYDRAULIC PIPE BENDING PRESS

LEEDS ENGINEERING AND HYDRAULIC COMPANY, LIMITED, RODLEY, ENGINEERS



HYDRAULIC PIPE-BENDING PRESS.

In the press illustrated on this page hydraulic pressure is successfully employed to supply the power necessary for bending large copper pipes. The general features of the press are obvious. It consists of a Y-shaped massive cast iron bed-plate, two arms of which carry adjustable roller brackets, and the third supports the power cylinder. The brackets are moved along their slides, according to the sizes of pipes and radii of bends required, by means of a ratchet lever and steel square-threaded screws engaging with gun-metal lock nuts. When in the desired position the brackets are locked by means of heavy cramp plates and bolts. The hydraulic cylinder is provided with an automatic draw-back motion shown in the sectional drawing. In this portion of the apparatus there are two concentric rams A B, the larger one A being for applying the pressure on the pipe, and the smaller one B being used for drawing the ram back again through the medium of the yoke-piece C and rods D D attached to the front flange of the ram A. The cylinder and large ram are made of a special hydraulic metal, carefully machined, and the cylinder is securely bolted and keyed to the bed-plate. The control of the pressure to both rams is effected by a Hargreaves hydraulic actuating valve. The machines are made in two sizes of 30 and 50 tons capacity, with a hydraulic pressure of 1500 lb. per square inch. They will take pipes 6in. and 12in. diameter, and are provided with mild steel adjustable tees for supporting the pipes while being bent. The pipe to be bent, after being first filled with resin, is placed across the machine in the desired position. The hydraulic valve is now opened to pressure, causing the large ram to move forward, and bending the pipe by means of the rollers carried on the pins of the two brackets and the die on the ram end. After the bend is completed the valve lever is moved to open the exhaust to the main ram, and this simultaneously brings into action the automatic "pull-back" ram B. This part of the machine is always subject to constant pressure, and when the contents of the cylinder are released the main ram A returns to its normal position. When pressure is again admitted to the ram A, this being of much larger diameter than the ram B, overcomes the constant pressure in the smaller cylinder, which empties itself through the constant pressure connection on the valve into the pressure water. If pressure from accumulator mains is not available, the machine is furnished with a hand pump to work at 1500 lb. per square inch, and the action of the machine remains the same. The machines are made by the Leeds Engineering and Hydraulic Company, Limited, Rodley, near Leeds, for any pressure from 700 lb. to 2000 lb. per square inch.



DETAILS OF PIPE BENDING PRESS

ADVICE TO YOUNG MOULDERS.

By An Old Hand.

In this age of severe competition it behoves every manufacturer and founder of iron and steel to be up to date in his methods of production, with as little waste and as limited a quantity of defective work as possible. I will endeavour in a rough manner to deal with the question of defective castings, their chief causes and prevention, from my view as iron moulder, and from experience gained in machine shops where castings have shown a great variety of defects, and given the moulder the principal keys to prevention. In the best regulated foundries there will always be a certain percentage of defective work, accidental or otherwise, and there is room left in most foundries for still further improvement and a reduced scrap heap. First, then, of great importance is the moulding-box question. The first, of machining box parts, and so getting a true joint, and preventing straining the castings is real economy. The boxes should be made with round ends, instead of the old-fashioned square ones, for, being rounded, the boxes are very much stronger and stand more strain. The pins should be slotted and made to fit closely the holes drilled to receive them. This is very important, as it prevents any twist that, most founders know, is a frequent cause of spoilt work. Having, then, up-to-date moulding boxes, next in importance is the moulding sand. This should be of an open nature, and, if required, grinding will make it close and tough for certain purposes. All parts of the pattern should be covered with facing sand, except those parts to be machined, which require more open sand; this enables the air to escape much more freely, both above and below the mould. Of course, this is immaterial in air-dried moulds, but for green sand moulds it ensures the castings against the small air or blow-holes that machining exposes. The skimming of iron before pouring is very important, and so is the heat at which the iron is cast. Provided there is the required number of risers, the metal should be cast as soon as it leaves the furnace, decent time being allowed to remove the scum properly, or machining will expose this dross later. Too much attention cannot be given to this skimming question. The git or runner question is also very important, so as to give the easiest and quickest flow of metal through the mould. And here I believe in the utility of running off where possible, as by making risers inside the mould above the pattern in the top parts you will collect all the skum and coke or dross which otherwise would be sure to go into the mould solid from running on. Running on is considered to give best results, as runners act as feeders, but the proper size of the runners, according to the weight of the casting, will put this matter right. For undried moulds the air or gas to be driven from the mould is the great question, and so the vent wire must be always used freely on both sides, and more so in the top parts, as the blow and air-holes are generally found in the top parts of castings, and the greatest strain is found here when casting. The too free use of the water brush on undried moulds is a great cause of defective work, as unnecessary moisture produces so much gas to be got rid of when casting; besides, this water chills the castings, and causes far more expense with steel cutting tools in turning and drilling or boring and planing. It is also of great importance to proportion the runners properly to the size of the pattern, so as to keep the mould full of iron when casting, because if the air is allowed to enter or escape from this direction scabbing will surely be caused, and sand will be displaced, and this sand will be found in the castings when in the machine shops. Avoid sleeking with trowel parts to be machined, as roughness is better than a glazed surface, and the latter is most likely to produce blow or air-holes. Sleeking with the trowel the top parts of the moulds is a great cause of castings being found defective when machined, as the air has been partly prevented from escaping from the mould.

A great source of trouble in some foundries is the burnt iron found in some scrap heaps, such as fire-bars, annealing pots, hardening pots, furnace bars and plates, burnt pipes or tanks. It requires very little burnt iron to spoil a half-ton ladle of iron. It is easily detected by its earthy red colour. It can only produce rotten castings, is absolutely useless for machine tool or engine castings, and once among the iron is similar to a disease, and not easily eradicated. Soft iron, too, is very troublesome, on account of its lazy travelling nature and great shrinkage. Castings with solid parts like pulleys, headstocks, brackets, &c., require sound judgment in casting to avoid the inward shrinkage that the boring machine or drilling exposes. But the great cause of defective castings with soft brands of iron is the running of moulds at too great a heat, so that the shrinkage occurs in the mould instead of in the ladle by allowing sufficient time to skim off all dross. See, too, that cores are properly vented and dried. Here, again, bosses will show this defect when drilled or bored. Air and water form two great enemies to the moulder, and strict attention to these enemies is absolutely necessary. Good relationship should exist between the moulder and pattern-maker, as both have always something to learn from each other, and working in harmony can assist the firm's interests, as well as their own, by suggestions in connection with their respective crafts. The moulds of light castings cannot be covered too quickly or vented too freely. Apprentices should be allowed to visit the machine shops, so as to see the defective castings on the planing or boring machines, or they should be shown them in the scrap heap. In this way they acquire more profitable knowledge, and study the cause and prevention on the spot. The heat of iron, hardness of top parts in green sand moulds, water, air, skimming, venting, proper sizes and position of runners are a few principal factors that require constant study and watchfulness, so as to prevent defective castings. It should be young moulders' study and delight to do their level best in preserving the trade and commerce of Old England.

ORE SEPARATION.

The question of the concentration of ores is one to which much attention has been devoted of recent years, and recently inventors have been busy in the new field of flotation processes in which the concentrate is removed from the top and the tailings from the bottom, apparently in contravention of the law of gravity. A new process has now been invented by Mr. A. P. S. Macquisten, and has been successfully applied in the United States. It is based on the utilisation of the surface tension of liquids, as exhibited in the old experiment of floating a sewing needle in water. Similarly, sulphide ores possess some property that prevents them from becoming wetted, whilst gangue minerals do not possess this property and readily sink. The finely-ground mineral in the form of pulp is fed into a horizontal revolving cast iron tube, and the tailings pass out at the other end into separating boxes, the feed and discharge being so regulated that the water passing over the opening or weir is about $\frac{1}{16}$in. deep. Internally the tube is cast with a helical groove and the pulp is screwed through the tube and repeatedly enabled to slide upon the surface of the water, where it may be retained by surface tension. On leaving the tube the gangue settles in the separating box, whilst the concentrates float away with the overflow of the surface layer of water into a collecting tank. At the Adelaide Mine, Nevada, where the process is applied to copper pyrites, iron pyrites, blende, and galena with heavy gangue minerals, the presence of which rendered ordinary methods of concentration ineffective, the tubes are each 6ft. long, 1ft. in inside diameter, and 450 lb. in weight, and rotate at thirty revolutions per minute. There are 100 tubes arranged in twenty-five groups

or series of four, which are traversed successively in twenty-four hours by five tons of ore. The proportion of copper in the ore varies from 2·7 to 3·2 per cent., and with the new process 90 per cent. of the metal is extracted. The process is too recent to enable conclusions to be drawn as to its cost. The results hitherto obtained are, however, promising, and the future development of this application of a principle of physics previously unemployed will be watched with interest.

A LARGE PLATFORM INDICATOR.

IN front of the main line booking-office at the new Victoria Station of the London, Brighton and South Coast Railway a large indicator has been erected, which shows at a glance the platform at which trains leave, and also the time of their departure and the stations at which they stop. While similar in construction to the indicator which has been in use at Liverpool-street Station for a considerable period, it is notable for the large number of stations it is capable of dealing with. Fig. 1 shows a front view of the indicator, from which the system on which it operates can easily be understood. The indicator is 24ft. long by 12ft. high, and it is divided into eighteen columns. It will be seen that each column is headed with a clock, and immediately below each clock there is a hexagon roller mounted in the indicator case. On the sides of these rollers metal plates are fixed, which bear the numbers of the various platforms. These rollers can be turned by means of small handles on the front of the case, so that any desired platform number may be brought into the openings at the top of the case.

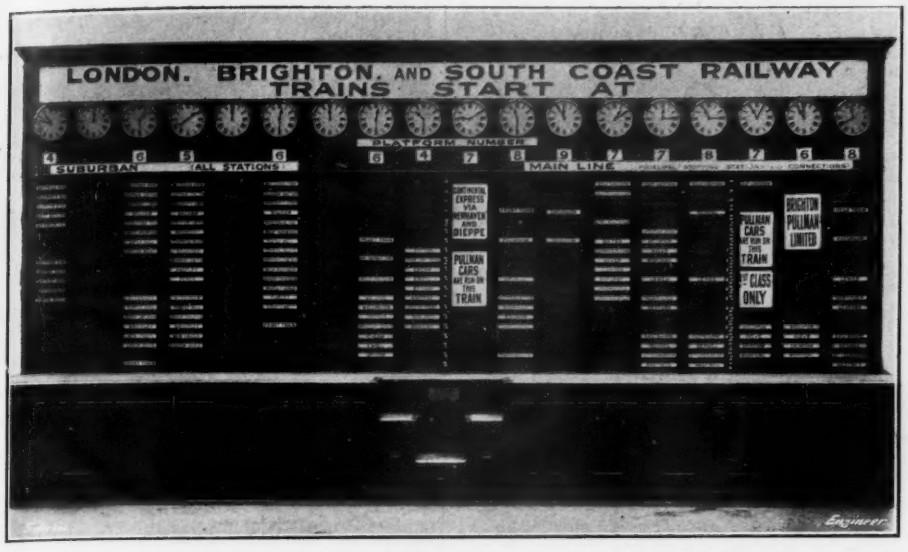


Fig. 1—PLATFORM TRAIN INDICATOR AT VICTORIA STATION, LONDON

Beneath each of these rollers there are twenty other rollers of similar construction, but of greater length; these rollers, which are operated in precisely the same manner as those described, are used for indicating the names of the stations. Each of these rollers has five sides available for station names; the indicator is thus capable of dealing with 1800 stations. At present, however, only 738 station names are fixed upon the rollers, the number being calculated to be ample for ordinary and special traffic. There are thus 1062 vacant spaces for future use, should the traffic reach such proportions.

The left-hand side of the indicator deals with suburban traffic, and shows every station at which the trains call. If any particular station is not shown, this means that the particular train indicated does not stop at it. The right-hand columns on the indicator deal with the main line, and show all stations to Tunbridge Wells, East Grinstead, Brighton and Horsham. Beyond these points the principal stopping stations are given, and all the branches running in connection. Suitably geared wheels are provided to the clocks for enabling the hands to be set as desired, the clocks being manipulated by a small knob at the side of each column. As far as possible each column is to be used for trains running in one direction.

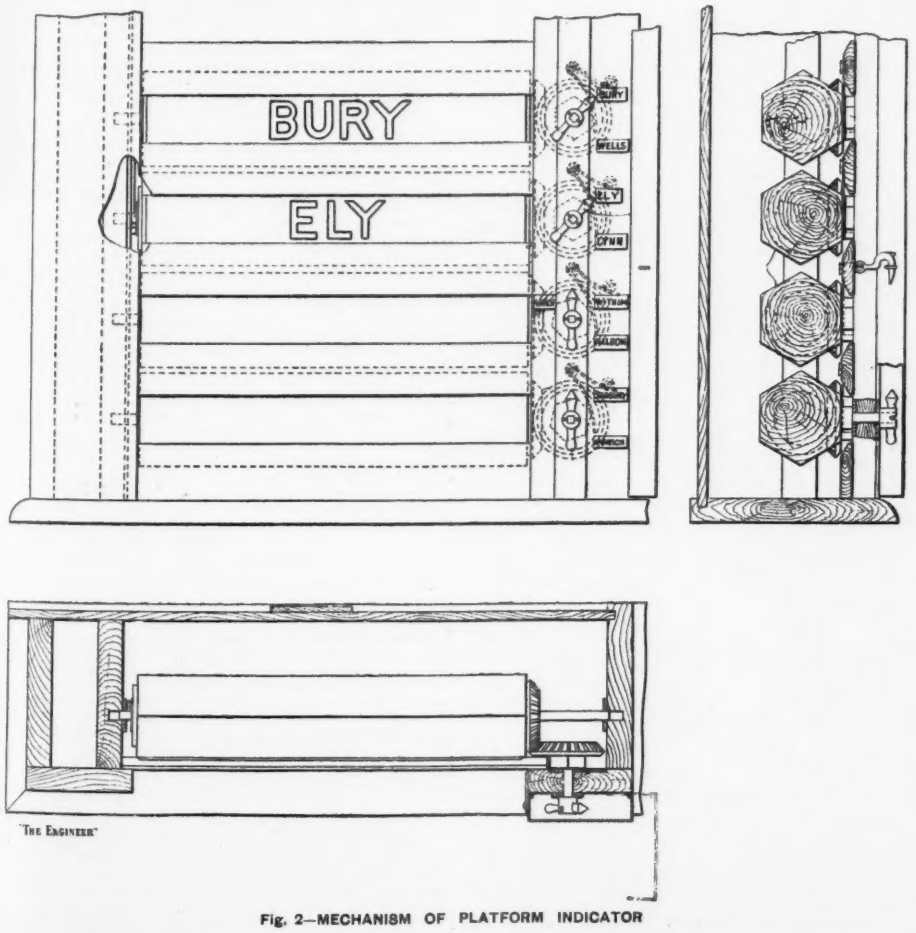


Fig. 2—MECHANISM OF PLATFORM INDICATOR

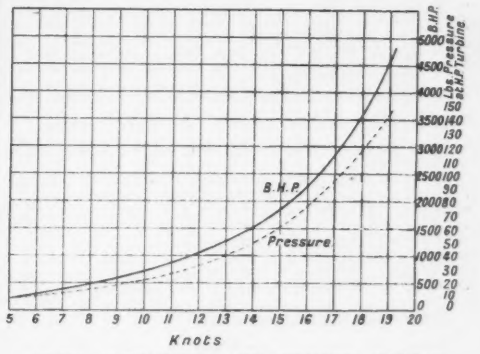
In Fig. 2 we give a drawing which shows a front elevation, a vertical section and a horizontal section of one of the columns. The front elevation is broken away at the left-hand side to show the spindle which supports one of the rollers. The projecting ends of the spindles are slid into grooves or slots in the side of the casing, the rollers being inserted at the back of the casing. Each handle for operating the rollers has a pointer at the opposite end, and under these pointers there are the various station names corresponding with those on the faces of the rollers, so that by setting a pointer to the name of a particular station the name of that station appears in the opening in the front of the case. The vertical section gives an end view of the hexagon rollers. Doors are hinged upon the front of the casing to cover the handles which operate the rollers. If desired these doors may be locked, so as to prevent unauthorised persons from tampering with the handles. From the horizontal section below the front elevation it will be seen that the motion imparted to the small handles in front of the case is transmitted to the rollers through the medium of bevel gearing, the gearing being situated in a small space which is provided at the sides of the columns.

The back and ends of the indicator are fitted with polished oak doors with glass panels, suitable for advertisements. Among the advantages claimed for the indicator is its adaptability to all circumstances without the trouble and expense of printing, as special plates are provided for everything in the shape of excursions, &c. Its durability is also another special feature, for since the movable parts are of gun-metal and name-plates of enamelled iron, the cost of maintenance is very little. The indicator is the invention of Mr. J. Howell, advertising inspector at the Liverpool-street Station, and it is manufactured by the Railway Indicator Company, 15, Colville-road, Leytonstone.

TRIALS OF THE TURBINE STEAMER CAMDEN.

AN interesting turbine vessel has recently been completed by the Bath Ironworks in Maine for the Eastern Steamship Company, of Boston, Mass., and the trial results have been given to the engineering world with the usual liberality affected by American builders regarding technical information. Built for the Nova Scotian passenger traffic, the Camden—and her sister ship Belfast, now being completed—is 320ft. long on the water-line, 40ft. beam and 9ft. 3in. mean draught. The corresponding displacement is 1825 tons. The vessel was designed for 17 knots, and is fitted with Parsons turbines of 4000 horse-power, consisting of a high-pressure turbine on the centre shaft and two low-pressure turbines on the wing shafts. Steam is supplied by cylindrical boilers with 256 sq. ft. of grate surface and 11,340 sq. ft. of heating surface; the pressure is 150 lb.

The high-pressure turbine rotor is 41in. diameter, with four expansions of blades; the low-pressure rotors are 58in. diameter, with eight expansions; the astern rotors on the same shaft are 47in. diameter. The shafts revolve at about 500 revolutions per minute, driving three-bladed propellers, 5ft. diameter and 4ft. pitch. There is one main condenser,



SPEED, HORSE-POWER, AND PRESSURE DIAGRAM

into which the two low-pressure turbines exhaust, of 4500 sq. ft., but a Parsons vacuum augmenter is also fitted, which involves the addition of a small augmenter condenser of 135 sq. ft.

The shafts were fitted with Denny and Johnson torsion meters, and in the figure are given the brake horse-powers corresponding to the speeds on the progressive trial, together with pressures of steam in the high-pressure receiver. These are tabulated below and plotted in the diagram above:—

Speed in knots.	Mean r.p.m.	Gauge pressure at H.P.	Shaft horse-power.
5	128	8	200
9	240	18	575
13	357	40	1275
15	419	61	1850
17	485	95	2855
19	555	144	4575

On the speed trial the boiler pressure was 143 lb., and the mean speed 18·6 knots. The engine data was as follows:—

	Port L.P.	H.P.	Starboard L.P.
Receiver pressure, lb.	18·2	132	15·5
Revolutions per minute	552	531	556
Shaft horse-power	1346	1463	1385
Total H.P.			4194
Vacuum			27·7in.
Condenser temperatures	43 deg. Fah. inlet, 75 deg. discharge		
Hot well			73 deg. Fah.
Feed-water			178 deg. Fah.

The apparent slip on the above trial was 11·45 per cent. on the high-pressure shaft and 15·08 on the low-pressure shafts, which is considerably less than in most turbine steamers.

A REPORT from Buenos Ayres states that the Minister of Public Works confirms the statement concerning the sale of the Andino Railway to the Central Argentine Railway Company at the price of 27,387,000 pesos (paper). The decree and message on the subject have already been drawn up, and will be sent to Congress this week. The Under-Secretary of State points out that the Buenos Ayres and Rosario and the Central Argentine Railway Companies, the amalgamation of which has not yet been accepted by the Argentine Government, although they are managed by the same persons in Buenos Ayres, constitute for financial matters a single company, the Buenos Ayres and Rosario Company having bought all the shares of the Central Argentine Railway. The journal *La Nacion* says that the transaction is undoubtedly advantageous to the State, and that the terms justify the alienation of this important public property.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

PRINCIPLES OF MECHANICS.

Sir,—The difference of opinion between Prof. Smith and myself is stated in his first and fifth paragraphs.

Prof. Smith assumes, as I understand him, that the fundamental formula for kinetic energy, for instance, is $\frac{1}{2}$ M v^2, wherein v may be considered as the velocity of M in reference to any geometric base; of which bases there may be, as he says, "a million." If, then, the velocities of any two masses be stated in reference to their common centre of gravity, there result two such expressions as the above, the sum of which gives their combined energy. If their velocities should be stated in reference to any other geometric base, of the "million" possible ones, we should get a new summation, giving their combined energy in reference to that base.

It is this entire concept of energy which my article was written to combat—not narrowly, by quibbling over detail, but broadly and fundamentally. Hoping to re-state my position more clearly, I add the following as fundamental mechanical principles:—

(1) Energy cannot be a property of a single body.

(2) Energy exists only as a property of the division and separation of mass into two or more units.

(3) The element of an energy fund is the relationship existing between two bodies only. That is to say, the energy fund of a system is divisible into as many component parts as there are pairs of bodies.

(4) Within each pair of bodies exists only one fund of energy, which is indivisible except as we distinguish between its two sorts, potential and kinetic; that is to say, the potential fund of the pair is indivisible, and so is the kinetic fund, although each is transformable, under certain rigid limits, into the form of the other.

(5) The energy of either or both of a pair of bodies may not be stated, in geometrical language, in reference to any other centre than the centre of mass, for no other centre may be even defined, geometrically, without reference to some third extraneous portion of mass, and the introduction of such a third mass portion introduces two new energy funds besides the original one.

(6) Energy may not be defined in reference to any merely geometric base; no body possesses energy in reference to a disembodied base; such a concept is purely a geometric one, not an energetic one; for a geometric base can neither attract nor repel, nor accelerate nor retard, a mass portion.

(7) Energetic relationships between mass portions alone constitute physical reality (that is, they alone exist indestructibly); geometric relationships are a figment of the brain, useful enough as such, but easily created and destroyed at any time, and therefore non-existent.

Without attempting to speak for other than American conditions, I would add, in general, that the simple formula $\frac{1}{2}$ M v^2 and its like are taught, not only widely, but universally, so far as engineering students are concerned, without the warning that they have arisen as approximations. These formulas did not arise from any accuracy of fact that the centre of reference might be made to coincide with the centre of either body. Both Newton and La Place knew the error of that idea. They recognised that the centre of reference must be the centre of mass. It was because that centre of mass lay very close, in the celestial pairs with which they worked, to the centre of one body, that they accepted, as an acknowledged approximation, the merging of the two centres into one. The bastard formula $\frac{1}{2}$ M v^2 which resulted we have inherited. The ignominy of the heritage we have forgotten.

Mr. Smith's insistence upon considering, as a part of the energy fund within a pair, the "elastic and plastic" and thermal energies, existent between the myriad of mass pairs constituting what we call a "unit body," is a confusion of the problem with gratuitous complexity. The internal molecular funds have nothing to do with the mechanical energy. The latter exists between the bodies of the pair. The former exists within each body and independently of the other between many minute portions of the same.

Sidney A. Reeve.

New Haven, Conn., November 30th.

THE STRENGTH OF RINGS.

Sir,—In Mr. G. James Wells' solution for the strength of a ring, he states that the B.M. at any point, "P," is

$$M = \frac{W}{2} \times (PQ) - M_1$$

$$= \frac{W}{2} . R \sin \theta - M_1,$$

$$\text{where } M_1 = \frac{W R}{\pi};$$

$$\therefore M = \frac{W}{2} . R \sin \theta - \frac{W R}{\pi}.$$

Now, at "D"—which I take to coincide with "B" in Fig. 2 of his letter of November 2nd—

$$\theta = 90 \text{ deg., and } \sin 90 \text{ deg.} = 1,$$

consequently at D (B),

$$M = \frac{W R}{2} - M_1,$$

$$= \frac{W R}{2} - \frac{W R}{\pi};$$

$$\text{(not as printed, } \frac{W R}{2} - M).$$

$$\text{Reducing, } \frac{W R}{2} - \frac{W R}{\pi} = W R \left(\frac{1}{2} - \frac{1}{\pi}\right)$$

$$= \cdot 182 \text{ W R,}$$

which is the B.M. at the side of the ring.

Now, at "A"—the point of application of the load—

$$\theta = 0, \text{ and } \sin \theta = 0,$$

consequently the expression

$$M = \frac{W}{2} . R \sin \theta - \frac{W R}{\pi}$$

simplifies to

$$M = - \frac{W R}{\pi}$$

$$= \cdot 318 \text{ W R,}$$

which, I take it, shows that the maximum B.M. occurs at the point of application of the load.

Such being the case, I do not understand why Mr. Wells goes to the trouble of working out a formula for the maximum stress at a point D, where the B.M. is not at its maximum, more particularly as he refers to a solution given in *Engineering* of April 13th, 1894, the connection to which, in the next issue, distinctly stated that the maximum B.M. = ·3186 W R—at the crown—and at the sides = ·1814 W R, the same as I have simplified his formula to.

I am open to a correction from Mr. Wells, or any other correspondent, but in support of my argument that the B.M. is greatest at the point of application of the load—the crown—would refer to *Engineering*, April 13th and 20th, 1894, and March, 1895; also Green's "Structural Mechanics," and the *Mechanical World* of May 29th, 1903.

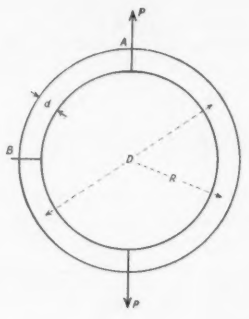
December 2nd. W. B.

Sir,—By an analysis similar to that given by Mr. G. J. Wells, but corrected as shown in a later issue by Mr. R. W. Bailey, the magnitude of the bending moments at section A and at section B can be obtained.

Bending moment at A = ·32 P R = ·16 P D;

and bending moment at B = ·18 P R = ·09 P D.

Again, if f_A be the tension stress induced by this bending



moment at section A and d be diameter of iron bar of which ring is made, then:—

$$\frac{\pi f d^3}{32} = \cdot 16 \text{ P D.}$$

$$\therefore f_A = \frac{1 \cdot 63 \text{ P D}}{d^3}.$$

Similarly, stress at section B due to bending moment:—

$$f_B = \frac{\cdot 91 \text{ P D}}{d^3}.$$

To this must be added the tension stress due to direct tension of which magnitude is $\frac{2 P}{\pi d^2} = \frac{\cdot 63 P}{d^2}$;

$$\therefore \text{ total stress at section B} = \frac{\cdot 91 \text{ P D}}{d^3} + \frac{\cdot 63 P}{d^2}.$$

Now, if stress at section A is to be equal to stress at section B, as it should be for economical design, then:—

$$\frac{1 \cdot 63 \text{ P D}}{d^3} = \frac{\cdot 91 \text{ P D}}{d^3} + \frac{\cdot 63 P}{d^2}$$

$$\therefore \frac{\cdot 52 \text{ P D}}{d^3} = \frac{\cdot 63 P}{d^2}$$

$$\therefore \frac{D}{d} = \frac{\cdot 63}{\cdot 52} = 1 \cdot 21.$$

Hence it appears that correct ratio of diameter of ring to diameter of bar forming the ring is 1·21:1.

Now, such a ring is impossible in practice, since it would be impossible to thread through the ring a link capable of exerting anything approaching the load which the ring could stand, or, in other words, the ring would be too fat.

Then, in practice, the ratio of $\frac{D}{d}$ cannot be less than 3:1. In this case, by slight consideration, we can see that the stress induced at section A is greater than stress induced at section B.

Hence, in designing a ring to support a given load, consideration must be given to the section at the point of application of the load, and not at the section 90 deg. distant from it.

London, December 4th. F. R. S. Rice.

FRICTION AND LUBRICATION.

Sir,—I am glad to see from Dr. Nicolson's letter in your last impression that he is about to add some explanatory matter to his most interesting paper, for it is, I think, very much needed. Dr. Nicolson seems to have hardly realised the magnitude of his proposition. During the last half-century, at least, engineers all over the world have designed and constructed bearings, and reached certain conclusions concerning their behaviour and the reasons for that behaviour, and now Dr. Nicolson writes:—"If, then, we lengthen the above hypothetical journal in order to improve its running, it is done not to lower the temperature, but because, by diminishing the bearing pressure, we have a larger margin for avoidance of the critical point. It is to be further observed that the higher the speed the shorter the journal may be. This is in direct contradiction to ordinary practice, which has been quite led astray on this point."

If this is right, then engineers have been entirely wrong hitherto. I think it is very improbable that they will accept this statement as representing the fact.

The assertion, however, that the higher the speed the shorter the journal may be is excessively indefinite, and before it is rejected as untenable it is necessary to know what it means. We want, that is to say, some definite figures. Take, for example, a bearing on a lay shaft revolving at 150 revolutions per minute, and 4in. in diameter. It is 8in. long, and the load is 300 lb. on the square inch. If, now, the speed is raised to 300 revolutions per minute, may the bearing be made 4in. long and the load increased to 600 lb. without any rise in temperature?

Practice has shown that there is a given length of bearing which for long shafting will run cool with a given speed. Dr. Nicolson, as I understand him, holds that the most that augmentation of length can do is to provide a larger cooling surface. But here, again, we have nothing definite. If we take a headstock with a wholly enclosed bearing spindle, we may well admit that lengthening the bearing will give a larger cooling surface, but this cannot apply to line shafting, when the whole shaft is cooling surface, out in the open. There are thousands of such bearings running in which the rise in temperature is quite trifling, and need not be taken into account at all. The true reason why bearings are made long is to reduce the load per square inch, and the possible load will depend on the material of which the bearing is made more than on anything else.

I take it for granted that the engines of torpedo boats are the result of an enormous number of experiments. I defy contradiction when I say that the lengths and every other dimension of the bearings in engines by Yarrow or Thornycroft are just as small as they can possibly be. Are we to assume that these dimensions are all wrong—right through from the engines to the stern tubes?

My contention is that practical engineers know quite well what they are about, and that the experiments cited by Dr. Nicolson are not of general but special application. Thus they may be, for anything I know to the contrary, accurately right for lathe bearings, yet I venture to think that few tool makers would venture to shorten their bearings very much. Engineers of all kinds are very much given to adhering to successful practice.

The rule hitherto has been to reduce speed when a bearing gets hot. I fancy there are few marine engineers who would put on more steam if a crank shaft bearing ran hot. I can hardly fancy an engine-driver with a hot axle-box trying to get another twenty miles an hour in the hope of cooling it.

Railway carriage axles are loaded to from 450 lb. to 500 lb. per inch in ordinary practice, and it has long been held that the reason why the resistance of trains is greater at slow than high speed is due to the lack of a film of oil following up at speeds below twenty miles an hour. But the evidence is very dubious. It is open to question whether the axle friction is greater at slow that at high speeds. Facts can be adduced on both sides. Is it not a very curious coincidence that railway engineers should "unconsciously design their journals to avoid the critical point by a small margin?" May I venture to say that the margin is very large, and that the modern railway axle-box is not in any way the result of unconscious cerebration, but of the most careful thought based on long experience.

Would Dr. Nicolson make the bearings in a first-class railway coach half the length of those for a goods wagon? If not, why not?

Finally, there are, says Dr. Nicolson, "no bearings running well in practice under pressures of tons per square inch, except when the sense of loading is continuously reversed." If he will go into any tin mill he will see such bearings, or into any black sheet mill, and if he has ever seen such a mill "stalled," he will have a valuable object lesson. There are in such mills no reversals. The lubricant is hot-neck grease. Any three-high mill has rolls always running the same way, and putting enormous loads on small strips of brass. I may add that rolls with 14in. to 18in. necks make 35 to 40 revolutions per minute. J. B. C.

December 10th.

LOCOMOTIVE ENGINE DRIVING.

Sir,—After perusing your correspondent's communication in your issue of the 8th ult. I cannot admit that my criticisms are unjustifiable. If his embryo driver knows nothing about signals, as your correspondent admits, then he knows little or nothing about the other important items that I mentioned; but he said he could make an engine driver in two days.

I note in his letter of November 29th that when drivers and firemen of no experience were put on engines when a strike occurred in one of our Colonies the number of trains and speeds were reduced; having been in the Colonies myself, I might say that neither trains nor speeds need much reducing, or there would be no train service left for the public, as poor is the best there.

Your correspondent claims to have had a wider footplate experience than myself, but here let me inform him that "footplate experience" is not driving an engine, as we drivers know when we get some of the aspirants to the regulator accompany us occasionally by permission of the superintendents.

As a picked, practical man and the driver of a "flyer"—one of the latest in this country—allow me to inform your correspondent it is quite unnecessary to leave the footplate to watch crossheads travelling, &c., and our journeys are performed daily without a hitch. He also displays his want of experience in driving when he says it is a common practice with careful drivers who are not too timorous. This, practical men call foolhardiness; and that his experience of footplates was obtained where they are not particular over a few stops with a fast train, is the conclusion of

An Express Driver.

The Old Stoneferry Waterworks, which at one time afforded the sole water supply for Hull, have lain idle since the opening of the Spring Head Works forty years ago. During the past summer it was determined to use one of these filtering beds as an open-air bath, and the matter was referred to a committee to make preparations, but up to the present there has been no such bath in use, and it is probable that that scheme will now be abandoned.

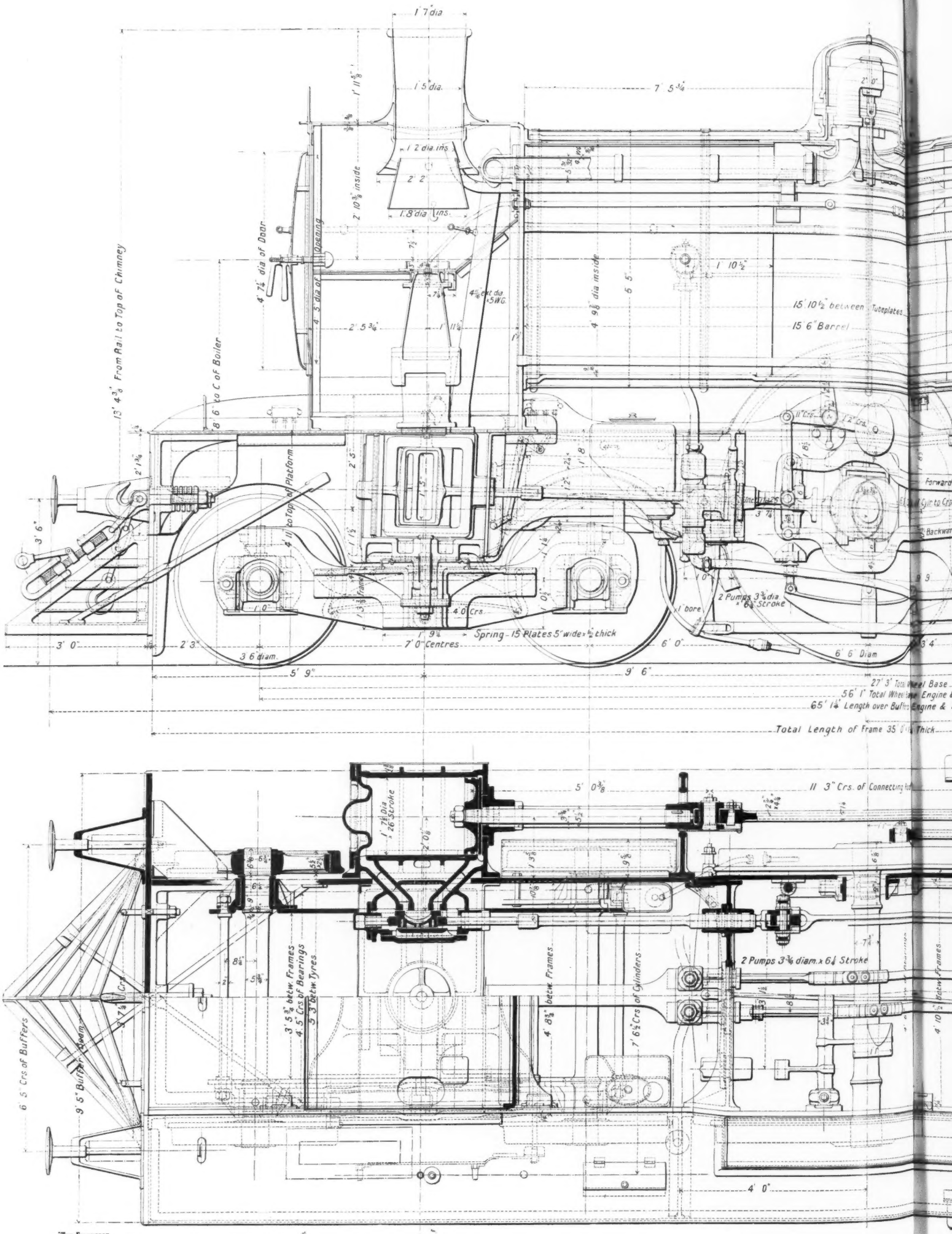
New Tramway Brake.—A sub-committee of the Municipal Tramways Association visited Burton-on-Trent last Friday evening, for the purpose of inspecting the new brake designed by Mr. P. J. Pringle, the borough electrical engineer and tramways manager. The main features claimed for this brake are that it is entirely mechanical; that its maximum power is instantaneous in application; that it requires no power to apply it; and that it calls for the most elementary motion, the conductor having equally the same control as the motorman. It is further claimed that these features almost entirely eliminate the personal element, which is always a very grave question.

The Junior Institution of Engineers.—A numerously attended visit of this Institution was recently paid to Woolwich Arsenal, appropriately arranged to follow the address on "Some Comparisons between French and English Artillery," which had been delivered by the newly-elected President, M. Gustave Canet, the French artillerist. The Chief Superintendent of Ordnance Factories, Mr. H. F. Donaldson, received the members, and under the guidance of the Chief Mechanical Engineer, Mr. Douglas Heap, and other officials, several hours were spent by the visitors in an inspection of the interesting processes of manufacture involved in the production of metal time fuses, bullets for the magazine rifle, siege, field quick-firing and machine gun carriages, mountings for heavy ordnance, woodwork for carriages, small arm and quick-firing ammunition boxes, wheels, heavy breech-loading guns, including the hoops and tubes for them. Rifling operations were shown, and working models of breech mechanisms of heavy breech-loading guns. The process of wire winding was also seen, and in view of M. Canet's observations on that topic in his address, attracted particular attention. The Chairman of the Institution, Mr. Frank R. Durham, expressed to Mr. Donaldson the members' appreciation of the special arrangements which he had kindly made for their reception, enabling so much to be seen in the limited time at disposal. At the ensuing meeting on January 8th, a paper on "Recent Improvements in Electric Conduit Construction" is to be read by Mr. Fitz Roy Roose, of the London County Council tramways reconstruction department.

Mining Explosives.—Professor Latham, M.I. Mech. E., recently appointed to the new Chair of Mining at Glasgow University, delivered a lecture on explosives at a meeting on the 5th inst. of the Glasgow University Engineering Society. In describing the construction of explosive mixtures in general, the lecturer divided them into three classes, those of the nitrate class, those of the nitrate derivative class, and those of the nitro-substitution class. The members of the first class are composed essentially of mixtures of nitrates and carbon in some form or other. The chief of them are gun-powder and blasting powder, both of which are very unsuitable for use in coal mines, owing to the explosive and poisonous nature of the gases evolved by their decomposition. They should be totally prohibited in coal mines. The best known member of the second class is nitro-glycerine, which is prepared by treating glycerine with nitric and sulphuric acids. The chief objection to its use is that it is a liquid, and hence its solvent derivatives, dynamite, gelignite, blasting gelatine, &c., are better for practical purposes. Dynamite is prepared by absorbing nitro-glycerine in the porous German earth "Kieselguhr." These mixtures have the advantage over gun-powder of giving off no combustible gases on explosion. To the third class belong chiefly compounds formed by "nitrating" certain hydrocarbons produced from coal tar. They are known as "Sprengel" explosives, and are by far the safest and most efficient explosive which can be used in mines. They give off no combustible gases on decomposition, and they can be handled with safety owing to their requiring very powerful detonation to explode them. Danger was, however, connected with them all, and mineowners should not grudge extra expense if in any way they could enhance the safety of their workmen.

ATLANTIC TYPE LOCOMOTIVE, GREAT I

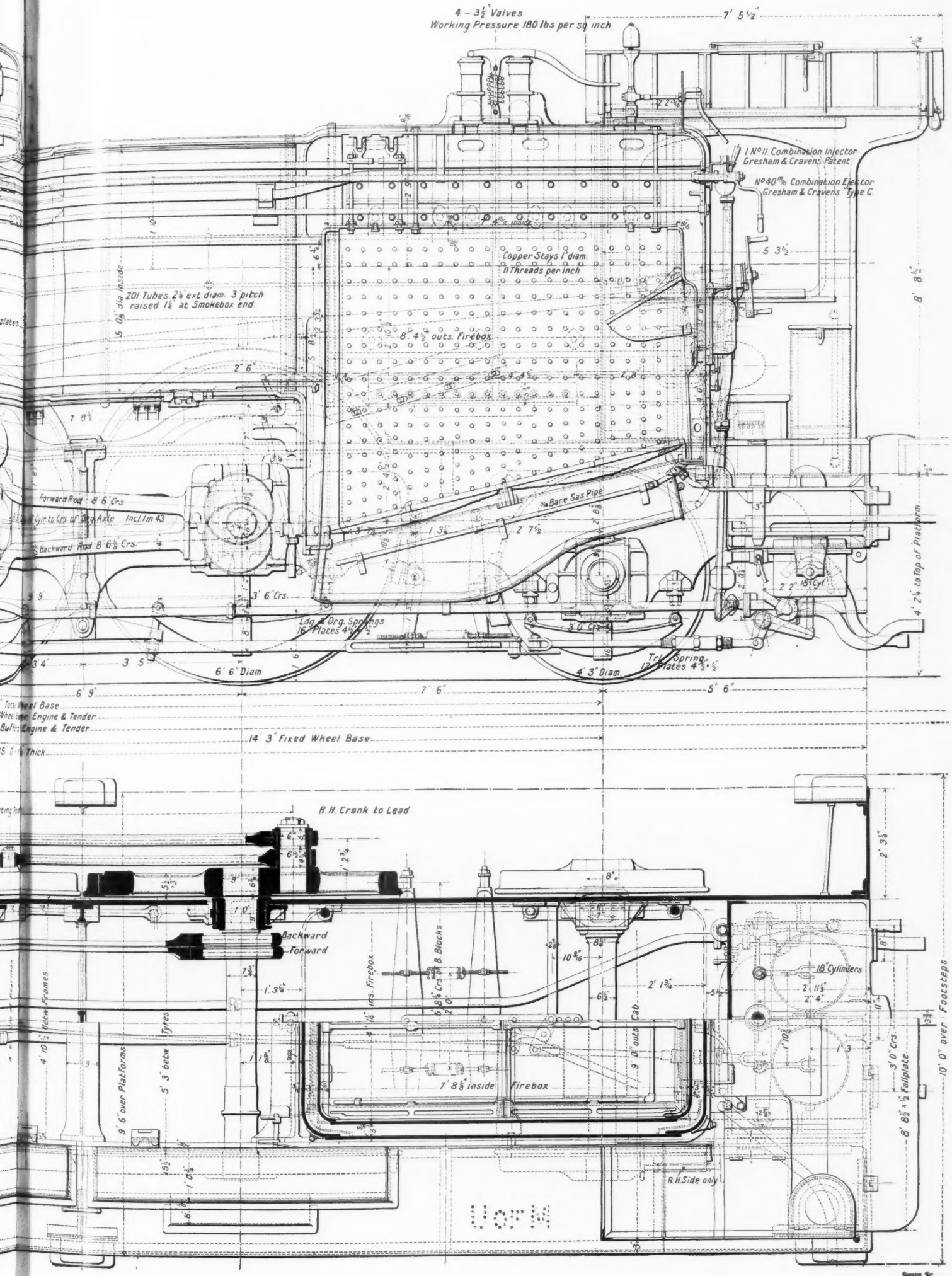
THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMI


1' 7" dia
1' 5" dia.
1' 2" dia ins.
2' 2"
1' 8" dia ins.
2' 10 3/8" inside
1' 11 5/8"
7' 5 3/4"
2' 0"
4' 7 1/8" dia of Door
4' 5" dia of Opening
13' 4 3/8" From Rail to Top of Chimney
8' 6" to C of Boiler
2' 5 3/4"
1' 11 1/8"
4 1/16" cut dia 5 WG.
4' 9 1/8" dia inside
6' 5"
1' 10 1/2"
15' 10 1/2" between Tubeplates
15' 6" Barrel
11" Crs.
12" Crs.
4' 11" to Top of Platform
2' 5"
1' 8"
3' 6"
1' 0"
4' 0" Crs.
1' 9 1/4" Spring 15 Plates 5" wide x 1/2 thick
7' 0" Centres
2 Pumps 3 3/8" dia x 6" Stroke
1' bore
3' 0"
2' 3"
3' 6" diam.
5' 9"
6' 0"
6' 6" Diam
9' 6"
27' 3" Total Wheel Base
56' 1" Total Wheelbase Engine &
65' 1 1/4" Length over Buffers Engine &
Total Length of Frame 35' 0" x Thick
5' 0 3/8"
11' 3" Crs. of Connecting Rods
1' 7 1/4" Dia x 26" Stroke
2' 0 1/8"
2 Pumps 3 3/8" diam. x 6" Stroke
6' 5" Crs of Buffers
9' 5" Buffer Beam
3' 5 3/8" betw. Frames
4' 5" Crs of Bearings
3' 3" betw. Tyres
4' 8 3/8" betw. Frames
7' 6 1/2" Crs of Cylinders
4' 0"

"THE ENGINEER"

GREAT INDIAN PENINSULAR RAILWAY

TIVE COMPANY, LIMITED, GLASGOW, ENGINEERS



600 HORSE-POWER TWO-CYCLE GAS ENGINE.

IN our issue of April 19th reference was made to an interesting gas engine which was being constructed by Mather and Platt, Limited, Manchester, for driving a cotton spinning mill. We are now enabled to place before our readers illustrations and more complete details of this engine, which is in successful operation at the Staley Mill, Stalybridge. It may be stated that although this mill is only producing medium counts, the running of the engine has so far been so steady, as shown by Moscrop records, that its adoption for driving mills in which the finest counts are produced would be quite safe. The engine is capable of developing about 600 horse-power on producer gas when running at 115¼ revolutions per minute. The gas plant has been installed by the Horsehay Company, Limited, and is operating on an inferior quality of coal obtained in the neighbourhood. The design of the engine is based upon the Körting patent, important improvements having been introduced by the builders to suit conditions of mill driving, namely, certain starting, even turning, and close governing. Being of the double-acting two-cycle type, an impulse is given to the crank shaft on every stroke. This gives the steady torque which is *a sine qua non* in cotton mill driving.

On page 598 are given photographic representations of the engine which we are about to describe. Fig. 1 shows longitudinal sections of one of the power cylinders and of the gas and air pumps—in the power cylinder drawing the stuffing-box is omitted; and Fig. 2 is a Moscrop indicator diagram reduced to one-third actual size, which was taken on November 20th last. The horizontal lines represent speed variations of 3 per cent. each. The engine-house contains, in addition to the main engine, a platform on which are placed the starting wheels; the main shaft, driven by thirteen ropes from the engine fly-wheel through the medium of a friction clutch; an air compressor, driven from the main shaft by a belt, the function of the compressor being to supply air under pressure for starting the engine; two pumps, one for circulating cooling water through the engine jackets and the other for providing cooling water for the piston, &c.; there are also in the basement compressed air reservoirs and a steam engine, the latter being provided as a stand-by for operating the compressor and pumps.

It will be observed that the engine is arranged on the twin system, the cylinders being 500 mm. bore and 820 mm. stroke, with a fly-wheel weighing 19 tons, and having thirteen rope grooves, placed centrally on the crank shaft. There are two separate bed-plates, each carrying its own engine and charging pumps. The latter are driven from the crank shaft by means of an overhanging crank and connecting-rod. At the front end of the power cylinders the piston-rods are carried through stuffing-boxes fitted with metallic packings, and are connected to external crossheads like a steam engine. Much importance is attached by the makers to this arrangement, as it obviates the difficulties arising from the heating of the internal crosshead pin used in Otto type engines, owing to the extremely high temperatures of combustion. It is further claimed that the outside crosshead minimises the wear of pistons, due to the resultant of the force of the impulse and the crank pin resistance. Added to these advantages is that of ease of lubrication. Another special feature is the length of the pistons, which, coupled with the external guides, ensure smooth running.

Messrs. Mather and Platt have made considerable alterations in the design of the charging pumps from those of Körting, although the functions remain the same. In one stroke they supply both the scavenging and explosive charges to the power cylinder. The double-acting pump A (Fig. 1) for the gas is now placed between the two single-acting air pumps B C. The three pumps are thus placed in line and secured to one another as well as to the engine bed-plate. They are, however, separated from each other by intermediate delivery valve boxes D E, each of which is divided by a diaphragm F into passages for the gas and air respectively, and is also fitted with automatic valves G H. The gas piston J is hollow. It is fitted on both faces with automatic valves K, and in its periphery are slots L. The wall of the gas cylinder is provided with suction ports, which open up communication between the cylinder and gas main when the ports are uncovered by the piston. When these ports are covered by the piston the gas is permitted to enter the piston itself, and then pass through the automatic valves K into the cylinder on each suction stroke. In order to delay the admission of the charge of gas into the power cylinder until the exhaust products from the previous explosion have been thoroughly scavenged by air—a necessary process in two-cycle engines—the piston J, at a predetermined point in its stroke fixed according to the heat value of the gas employed, over-runs the ports referred to, thus cutting off the gas supply, and then by its further movement forces the gas through the automatic valves H into one or other of the valve boxes D E, and thence to the gas passages to the power cylinder. The single-acting air pump B is extended to act as a slide for the crosshead and connecting-rod by which the pumps are operated. Passages cast in the engine bed provide communication between the ends of the gas pump cylinder and the back air-pump cylinder and the main inlet valves of the power cylinder.

The action of the power and charging cylinders is as follows:—When the engine piston is on the forward dead centre, as represented, the exhaust ports S round the walls are uncovered. At the moment that the pressure in the cylinder falls to that of the atmosphere the admission valve is opened by its cam, and a scavenging charge of pure air is sent through the cylinder by the air pump. The gas pump then sends a supply of gas into the cylinder, and this, mingling with the air previously sent in, forms the explosive mixture for the power stroke. The exhaust ports S are then closed by the return stroke of the piston, and the mixture is compressed and ignited, and then the working stroke takes place. The same cycle is repeated at each end alternately. It is claimed that the effect of a thorough scavenging of the burnt gases is to increase the power of the engine. In addition to this, the cleansing action of the air charge prevents the choking of the exhaust ports by carbonaceous deposits or dust from the gas. We are informed that, after months of work, an inspection of the cylinders of these engines has confirmed the latter statement. A further advantage of the system is that the air and gas may be independently controlled, being kept distinct till they reach the admission valve, and there is no accumulation of explosive mixture except in the engine cylinders. The regulation of the running of the engine is effected by varying the quantity and not the quality of the mixture. Steps have been taken to guard against the possibility of gas escaping through the exhaust ports by improving the design of the charging pumps, which, besides securing their object, have also reduced the loss in the pumps themselves, so that in normal conditions of working the loss on these heads should not be more than 7 per cent. to 8 per cent.

It has been found by practical observation that the weaker gases obtained from blast furnaces and producers require to be ignited earlier in the stroke, and to enable the time of ignition to be altered two sets of low-tension magneto apparatus are provided at each end of the cylinders, arrangements being made to enable the timing of the spark to be altered By providing the apparatus in duplicate a further advantage is gained whereby one set may be removed for cleaning or repair without stopping the engine. The gear for operating the induction valves differs materially from the original apparatus; no lay shaft with its attendant skew or bevel gear is employed. The valves A are of the inverted mushroom type, with springs C to keep them tight against their seats. Above each valve spindle is placed a pair of rolling levers D E, and the depression of the latter opens the valve. As the inlet valves require to be open during only about one-fourth the revolution of the crank shaft, the surfaces of the levers are so shaped as to produce a rapid movement of the valve spindle on opening and closing, allowing a prolonged pause during the remainder of the revolution. The two pairs of levers are connected by a rod F, so as to open their valves alternately. Their operation is effected by means of a connecting-rod G and the single excentric H on the crank shaft.

The engine is started by the admission of compressed air at a pressure of 120 lb. into the cylinders. A separate starting valve is provided, and the engine gets under way immediately. After making a few revolutions, and the gas valve being open, the compressed air valve is closed and the engine draws and ignites its own charge. The power cylinders are thoroughly water-jacketed, including the cylinder covers and exhaust port belt. Water circulation is also maintained through the crossheads, piston-rods, and pistons. An efficient system of forced lubrication is also provided for the working parts of the engine, cylinders, stuffing-boxes, and main bearings. It will have been observed that the engine has no exhaust valves and seats, which are frequent sources of trouble and require periodical grinding in. The induction valve gear is simple, and all working parts are easy of access, every part being reached from the engine-room floor. When we inspected the working of the engine, the running resembled very closely that of a cross-compound steam engine, for which it might almost have been mistaken. The evenness of turning is clearly demonstrated by the Moscrop diagram, which shows a variation of speed of less than 1 per cent. either way. We are informed that no trouble has been experienced in starting. The governor employed is of the Chorlton-Whitehead centrifugal pattern, which runs in oil, and has the dashpot in the weights. The governing valves are situated in a by-pass, connecting two ends of the gas pump. The governing takes place on the charging stroke of the pump, which immediately precedes the firing stroke. The valves are operated from the governors by means of a rod and shaft, running in ball bearings. This method of control gives such close governing that when the load is taken off the engine there is no material increase in its speed. A word of praise is due to the manner in which the exhaust has been silenced. The consulting engineer under whose supervision this engine has been installed is Mr. Norman Macbeth, of Macbeth Brothers, Bolton.

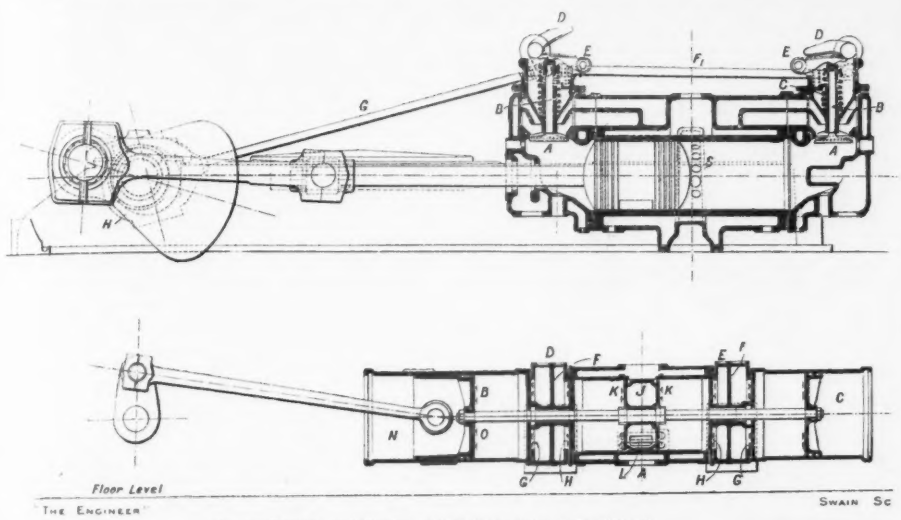


Fig. 1—POWER CYLINDER AND GAS AND AIR PUMPS

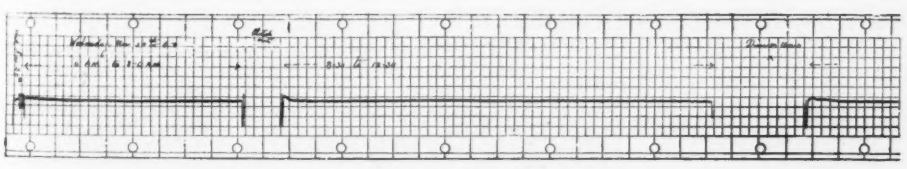
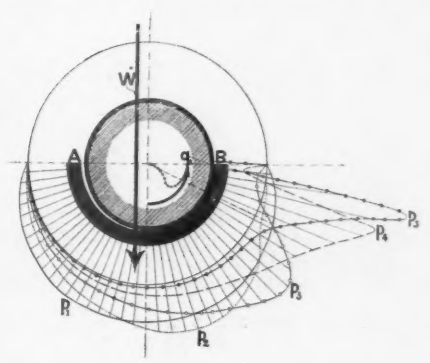


Fig. 2—SPEED REGULATION DIAGRAM

MANCHESTER ASSOCIATION OF ENGINEERS.

THE adjourned discussion of Dr. J. T. Nicolson's paper on "Friction and Lubrication" was resumed by members of the Manchester Association of Engineers on Monday last. The president, Mr. J. Adamson, announced that before the discussion was commenced the author wished to read some additional matter, which he had considered desirable to incorporate with the paper. The distribution of pressure round a journal running in a half-brass, according to Sommerfeld, was shown by the accompanying new diagram—Fig. 3*a*. The point of nearest approach was, as stated in the earlier part of the paper, situated midway between the maximum and minimum pressure valves. But it was shown that that point is no longer situated at the end of a horizontal diameter as it was in the bush bearing. It approaches very near that point when the speed is small or the load great, but recedes from it as the speed increases or the load diminishes, until at a very high speed, or with an unloaded journal it runs almost centrally. The curve within the shaft—Fig. 3*a*—shows on a highly exaggerated scale the way in which the centre of the journal shifts during the above-mentioned changes. Dr. Nicolson next introduced further diagrams showing graphically the frictional work per square inch of shaft under different conditions. He also added a section to his paper dealing with "The Factor of Safety," in which he explained that the lengths of bearings previously calculated were minimum values which could not be diminished without rupture of the oil film. The formulæ for calculating the necessary factor will be included in our second abstract of the paper.



The discussion which followed the second reading of the paper was not of a theoretical nature. Mr. Atkinson described a simple and somewhat primitive appliance by which he had attempted to measure the thickness of the oil film on a journal while revolving. He had concluded that this thickness was about $\frac{5}{1000}$in. Mr. Buck pointed out a discrepancy in the paper, and Mr. Alfred Saxon challenged the application of the conclusions arrived at by the author to practical conditions. He promised to arrange to have bearings, designed in accordance with the author's theories, placed in cotton mills to test their working, if the author would provide them. Mr. Saxon also suggested that a Research Committee of the Society be formed, with Dr. Nicolson at its head, to carry out experiments on the subject, and follow the example set by the Bradford Engineering Society. The author replied to the remarks on his paper.

ACCORDING to *Nature*, a captive balloon held by 4500ft. of No. 19 S.W.G. tinned piano wire was struck by lightning in the form of a cross flash from the cloud. The heat developed appears to have been sufficient to melt the tin, but not to fuse the wire. If it is assumed that the process is too rapid for loss of heat by conduction the heat energy must be between the limits $6 \times 1400 \times 200 \times 0{\cdot}11$ and $6 \times 1400 \times 1300 \times 0{\cdot}18$ in gm.-cals., the wire weighing about 6 gm. per m. and the mean specific heat of steel from 0 deg. to 1300 deg. Cent. being taken to be 0·18. In ergs the limits are $7{\cdot}12 \times 10^{12}$ and $8{\cdot}28 \times 10^{13}$, or, assuming the height of the cloud to be 100 m., the energy was sufficient to raise 73 kilos., but not sufficient to raise 840 kilos. to the cloud level.

LABOUR-SAVING APPLIANCES AT THE MINES OF THE NEW KLEINFONTEIN COMPANY, TRANSVAAL.*

By Mr. EDWARD J. WAY, Member, of Johannesburg.

(*Concluded from page 582.*)

BEFORE the war an average of about 20,000 tons of rock per month was mined underground and hoisted to the surface for treatment in the old 160-stamp mill reduction plant, while at the present time the average number of tons sent to the surface for treatment in the new 200-stamp mill reduction plant is about 47,000 a month. The number of unskilled coloured labourers required to handle this increased tonnage between the ore bins of the three headgears and the mill ore bins by means of the mechanical haulages of the old plant, calculated on the basis of the old labour returns, would have approximated 344 per day. At the present time the number employed only averages 50 a day, thus showing a reduction in the amount of unskilled coloured labour employed

Fig. 4—CUTTING FOR CONVEYOR

on this section of the plant of 294 men a day, as given in detail in Table II. :—

TABLE II.—*Unskilled Coloured Labour Employed in Ore Handling between the Ore Bins of the Three Headgears and the Mill Ore Bins.*

Nature of employment.	Employed on old plant, on basis of tonnage handled at the present time.	Employed on present plant.	Reduction in number of unskilled coloured labourers employed.
Handling ore between headgear ore bins and crusher station	151	43	108
Handling ore in crusher station (not including sorting boys) and from crusher station to mill	139	3	136
Depositing the "fines" in the mill ore bins ..	54	4	50
Total reduction in unskilled labour			294

The conveyor system—handling ashes, waste rock and residue

Fig. 5—SECOND AND THIRD SECTIONS OF WASTE CONVEYOR

sands—consists of the main waste conveyor divided into five sections, which runs to the dump, and of three subsidiary conveyors, one feeding the waste rock from the waste rock bins of the crusher station on to the first section of the main waste conveyor, and two feeding the residue sands from the sands treatment tanks of the cyanide plant on to the second section of that belt.

The waste rock conveyor runs horizontally below the feeder chutes of the waste rock bins under the crusher station, and delivers the waste rock from those bins on to the tail end of the first section of the main waste belt running at right angles to and below the waste rock conveyor. It is driven at its head end by bevel gearing from the tail end of the first section of the main waste conveyor, the power being transmitted by this belt from the 50 horse-power motor driving its head end. The belt is 30in. wide and 52ft. 6in. long between pulley centres, runs at a velocity of 260ft. per minute, and has a normal carrying capacity of 112 tons per hour. The average amount handled per day amounts to about 528 tons.

The sands treatment tanks, 50ft. diameter, are arranged in two rows, and each is provided with twelve discharge doors 18in. in diameter, and with hoppers and steel chutes sloping downwards from these doors and delivering the residue sands directly on to the two residue sands conveyors. These conveyors run one below each row of tanks in cuttings about 15ft. below ground level, and feed the residue sands on to the second section of the main waste conveyor. Each belt is driven at its head end by a 15 horse-power motor at a speed of 486ft. per minute, and has a normal carrying capacity of 170 tons per hour. They are 18in. wide and 285ft 6in. long between pulley centres, and handle between them an average of 800 tons per day.

The first section of the main waste conveyor runs horizontally from the waste rock belt up to a deep cutting—situated at right angles to it—and to the two residue sands conveyors, along which the second section of the main waste conveyor runs, Fig. 4. Starting below and at right angles to the waste rock belt it runs first through a weighing room, where the waste rock is weighed by a Blake-Denison weighing machine similar in every respect to the one described in connection with the "fines" belt in the mill; it then passes below the two ash storage bins and on to its head end, where it discharges the waste rock and ashes on to a chute, which feeds them on to the second section of the main waste conveyor. The belt is 30in. wide and 454ft. long between pulley centres, and is driven at its head end at a speed of 275ft. per minute by a 50 horse-power motor, and, as previously mentioned, transmits the power necessary for operating the waste rock belt. It has a normal carrying capacity of 116 tons per hour, and on an average handles each day 528 tons of waste rock and 30 tons of ashes.

The second section of the main waste belt starts below the head end of the first section and runs horizontally in the deep cutting previously mentioned—necessitated by the depth at which the two conveyors running below the sands-treatment tanks deliver the residue sands on to this portion of the main belt—for a distance of 110ft.; and then, bending round a curve of 250ft. radius, it rises to the surface and proceeds at an inclination of 19½ deg. to its head end at a point 60ft. 6in. above the ground level, where it discharges the waste rock, ashes and residue sands on to the third section of the main belt. The part of the conveyor above ground level is carried by steel channels, supported by three light steel intermediate trestles and a tower of light steelwork. The top platform of this tower forms the floor of a motor-house containing two 50 horse-power motors, one of which drives the head end of this section of the main conveyor and the other the tail end of the third section. The belt is 355ft. long between pulley centres, and is 30in. wide, and, when running at its normal speed of 295ft. per minute, has a carrying capacity of 284 tons per hour.

The third section of the conveyor continues upwards at an angle of 18 deg. to a height of 130ft. above the ground level, and is carried by a light steel girder, formed of two inverted bowstring trusses, in a single span of 195ft., from the tower just mentioned in connection with the second section of this conveyor to an end tower built up of steel sections—Fig. 5. The belt is 30in. wide and 197ft. long between pulley centres, runs at a speed of 320ft. per minute, and has a normal carrying capacity of 284 tons per hour. It discharges the waste rock, ashes and residue sands on to the fourth section of the conveyor—the distributing belt proper—Fig. 6, at a height of 130ft. above the ground level.

This belt, 30in. wide and 140ft. long between pulley centres, is carried by a horizontal boom, built up of light steel sections, riveted at one end to the bottom of a steel mast 60ft. high and supported at intervals of 20ft. by steel ropes from the top of the mast. The mast, constructed of steel angles strengthened by transverse and cross bracing, is guyed to the ground by means of steel ropes secured to a revolving collar on its upper end, and is riveted at its lower end to a turntable, which can be revolved on a steel pivot supported on the top platform of the end tower through an angle of 175 deg., carrying with it the mast, boom and distributing belt. This section of the main waste conveyor, which is driven at a speed of 340ft. per minute by a 10 horse-power motor placed at the end tower, and which has a carrying capacity of 284 tons per hour, was not requisitioned until the waste rock, ashes, and residue sands falling over the head end of the third section had completely buried the end tower. The steel mast and a 20ft. length of the boom were then erected, and, as the dump extended, additional lengths were added until the distributing belt had attained its maximum length of 140ft., when it became necessary to erect and to make use of the fifth and final section of the conveyor—Fig. 7.

The boom and the old distributing belt were then reduced in length to 60ft. and arranged to feed on to the new distributing conveyor, a belt 30in. wide and 160ft. long carried by a double steel cantilever, 164ft. long, having an overhang of 60ft. beyond the edge of the dump. The cantilever is riveted at its centre to a turntable secured to a carriage running along a track, laid about 20ft. from the edge of the dump, forming an arc of a circle subtending an angle of about 170 deg., and having the steel mast as a centre and the fourth and fifth sections of the conveyor as a radius. It is moved round this arc as the dump fills up, and its travel along any arc having been completed, the rails are shifted forward 60ft. and the fourth section of the conveyor and the boom carrying it increased by a like amount, so as to still feed on to the distributing belt, when the cycle of operations is begun again and repeated as often as the growing dump requires it. The turntable carrying the cantilever is constructed so that the cantilever, at each end of its travel round the edge of the dump can be swung round on its carriage, until it is at right angles to the radius of its arc of travel. This is done in order to allow the distributing belt to fill up the corners of the dump, and so keep the angle subtended by the arc of travel constant, otherwise the dump, owing to the necessity of keeping the track rails at least 20ft. from its edge, would gradually come to a point and render the whole plant useless in the course of a few years.

The first half of the last section of the conveyor slopes upwards at an angle of 5 deg., and the other half at an angle of 10 deg., so that the top of the dump is inclined at an angle of between 7 deg. and 8 deg., and, consequently, its height gradually increases as it extends. The belt is driven at 340ft. per minute by a 15 horse-power motor carried on the cantilever, and has a normal capacity of 284 tons per hour.

The average daily tonnage handled by the last four sections of the main waste conveyor amounts to 1358, made up of 30 tons of ashes, 528 tons of waste rock, and 800 tons of residue sands.

TABLE III.—*Unskilled Coloured Labour Employed in Removing Waste Rock and Residue Sands to Main Waste Dump.*

Nature of employment.	Employed on old plant, on basis of tonnage handled at the present time.	Employed on present plant.	Reduction in number of unskilled coloured labourers employed.
Handling waste rock from crusher station to dump	33	3	30
Handling residue sands from sands-treatment tanks to dump	65	4	61
Distributing residue sands on dump	111	4	107
Total reduction in unskilled coloured labour			198

As previously mentioned, the amount of rock mined and hoisted to the surface per month has increased from an average of about 20,000 tons on the old plant before the war to an average of about 47,000 tons at the present time. Allowing for this increase and estimating on the daily labour returns before the war, the number of unskilled coloured labourers required to deal successfully with the increased tonnages of waste rock and residue sands by the mechanical haulages of the old plant would have approached 209 per day, while on the present plant the number engaged only averages 11 per day, showing a saving on this count alone, as indicated in Table III., of 198 men per day.

The installation of a belt conveyor system for handling waste rock and residue sands in place of the mechanical haulages of the old plant has not only effected the above large saving in unskilled coloured labour, but has also resulted in a very considerable reduction in the working costs. Before the war, on the old plant, the cost of removing the waste rock from the crusher station and the residue sands from the sands treatment tanks and of depositing them on the main waste dump was 7·5d. per ton milled, while at the present time the cost, including maintenance and depreciation, is only 1·9d., a saving per ton milled of no less than 5·6d., or, on the tonnage milled at the present time, of £770 per month, an amount which, in the course of the next two years, will completely pay off the total capital expenditure on the whole of the present surface-conveying equipment.

The total reduction in unskilled coloured labour employed on the surface, resulting from the installation of the very complete system of conveying belts and of the other labour-saving appliances just described, thus amounts to 630 men, made up as shown in Table IV.

TABLE IV.—*Unskilled Coloured Labour Employed on the Surface.*

Nature of employment.	Employed on old plant, on basis of tonnage handled at the present time.	Employed on present plant.	Reduction in number of unskilled coloured labourers employed.
In transferring coal from railway trucks to boiler furnaces, and ash from ash hoppers to main waste dump	159	21	138
In handling ore between the ore bins of the three headgears and the mill bins	344	50	294
In conveying waste rock and residue sands from crusher station and sands treatment tanks to main waste dump..	209	11	198
Total reduction in the number of unskilled coloured labourers employed on the surface			630

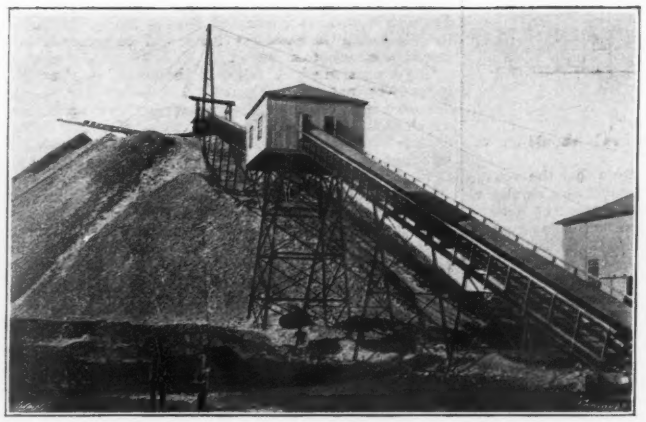


Fig. 6—FOURTH SECTION OF MAIN WASTE CONVEYOR

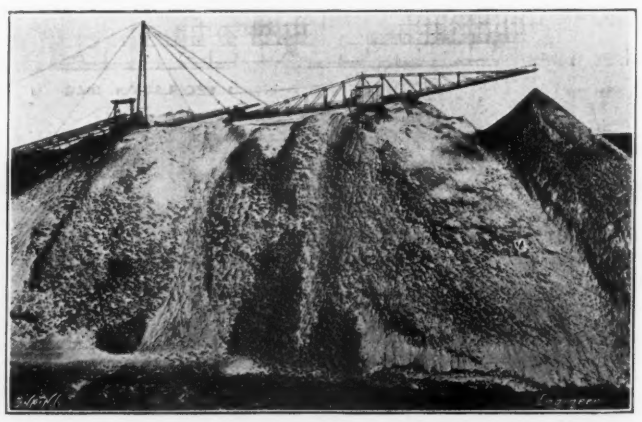


Fig. 7—FIFTH SECTION OF MAIN WASTE CONVEYOR

The great bulk of the unskilled coloured labour employed underground may be divided into three sections: hand drilling, shovelling the ore down the stopes, and hand tramming. The existing system of mining makes it economically impossible to substitute mechanical traction for the method of hand tramming at present in use, while the complete replacement of hand drilling by power drills is not at present feasible. The possibilities of any

* The Institution of Mechanical Engineers.

reduction in the number of unskilled coloured labourers employed underground are, therefore, limited for the present to the installation, in place of the existing method of hand shovelling, of some conveyor system of handling the broken rock in those stopes where the dip of the reef is not sufficiently steep to cause it to roll down from the working faces to the stope boxes, in readiness for loading into the underground trucks for conveyance to the shafts, and to the employment of an efficient stoping drill which would drill the equivalent of five to seven hand holes per day.

As the "backs" are some 200ft. long, many of the working faces of the stopes are over 200ft. in length, and it will be readily understood that, under the method of hand shovelling at present in use on the greater number of the mines, a large amount of unskilled coloured labour is required to shift the broken rock down the stopes, the majority of which are inclined at about 26 deg. to the horizontal. Any conveyor system which could economically do this work would result in a large reduction in the number of unskilled coloured labourers required.

The chief difficulty which had to be faced in the installation of such a system was the fact that the working faces of the stopes were constantly shifting, and so, whatever type of conveyor it was decided to employ, it would have been necessary to take it down and re-erect it at each blast. The method of operating the conveyor was a further difficulty, as any system requiring a power drive was impossible, both from the point of view of capital expenditure and running costs, and on account of the mechanical difficulties due to the conditions under which the conveyors would have had to work in the stopes.

These difficulties have, however, been overcome by the adoption of swinging conveyors hung from the hanging wall of the stope by chains, and operated, according to the length of the conveyor, by one or more men pulling on their upper ends. The conveyors are 18in. wide, and vary in length, according to the state of development of the stopes, from a maximum of 224ft. to a minimum of 32ft. In order to permit easy handling they are built up in 8ft. lengths of ¼in. iron plates slightly troughed. The bottom end of each length is designed to fit into the top end of the length below it, and is secured to it by means of two eye-bolts, one on each side. Square heads forged on the shanks of these eye-bolts are passed through square holes in the overlapping sides of the adjoining lengths of the conveyor, and the shanks are then slipped upwards into slots which just fit them; the adjacent lengths are thus secured together, while, at the same time, a little play is allowed between them and a certain amount of flexibility is given to the whole conveyor. The conveyor is suspended close to the working face of the stope by means of short lengths of chain hooked into the eye-bolts, the two chains from each pair of eye-bolts being secured to a single chain hung from a hook-bolt wedged into a hole drilled in the hanging wall of the stope. This method of construction was found to permit of very rapid handling, it being possible to take down and re-erect a conveyor 224ft. long in about forty-five minutes; while each time a conveyor is shifted, owing to the advancement of the working face, it is only necessary to drill one more hole in the hanging-wall than there are 8ft. lengths in the conveyor, that is, for a conveyor 224ft. long only twenty-nine holes are required.

The conveyor is hung as close as possible to the working face, for convenience of shovelling, and is taken down and put up again at each blast. When the working face has advanced about 6ft., a fresh series of holes is drilled in the hanging wall, and the conveyor is again brought close up to the face of the stope. The conveyors are operated, according to their length, by one or more men pulling on ropes attached to the upper end of the conveyor. The men pull up the conveyor and then let it swing back by gravity, the jerks thus transmitted to the ore causing it to slide down the conveyor, and to be discharged at its lower end.

The reduction in the amount of unskilled coloured labour employed in the different stopes depends, of course, upon the length of conveyor required, varying from about twenty-two men on a conveyor 224ft. long to three men on one 32ft. long. The number of conveyors in use at the present time is fifty-five, and a further fifteen are being made to complete the equipment of the mine, so that the total number ultimately in use will be seventy. As the average saving in labour works out at about six men per conveyor, the total reduction in the number of unskilled coloured labourers engaged in shovelling the ore down the stopes, resulting from the installation of the system of stope conveyors, will be about 420 men.

It will thus be seen that the total reduction in the number of unskilled coloured labourers, effected by the labour-saving appliances in use on the surface and underground, amounts to 1050 men, made up of a reduction of 630 men on the surface, and of 420 men underground. This number, of course, refers to the number of men who are required to put in a complete shift each day, and to enable this to be accomplished, the above number must be increased by about 15 per cent. to allow for loafers, by 3 per cent. to allow for men incapacitated through sickness or accident, and by a further 2 per cent. to allow for men employed on the compound and hospital staffs, thus bringing up the actual total reduction to 1267.

Coming now to the financial side of the question, each of the above unskilled coloured labourers, whether Coolie or Kaffir, costs the mine, including the compound, medical and sanitary charges, and allowing for shifts lost through sickness and the numerous Chinese holidays, about 2s. 4½d. per day, or approximately £43 6s. 10½d. a year. The annual saving effected by the reduction in unskilled coloured labour, resulting from the installation of the labour-saving appliances already described, thus amounts to £54,918, while in addition to this annual saving there has been a saving in capital expenditure on compound and hospital accommodation of fully £8000.

Against this must be charged the increase in the depreciation on the underground and surface-conveying installation, due to the far heavier capital expenditure incurred on the equipment of this section of the new plant, also the increase in their running and maintenance costs, which together amount to an annual charge, as shown in detail below, of approximately £7698.

TABLE V.

NEW PLANT.

(*Monthly Costs.*) *Running Costs* (*not including Labour*).

	£	£
Railways and rolling stock	173	
Surface conveyors	238	
Mechanical haulages	41	
Mechanical stokers	39	
	—	491
Maintenance.		
Railways and rolling stock	83	
Underground swinging conveyors	150	
Surface conveyors (belts only)	305	
Surface conveyors, general repairs	235	
Mechanical haulages	18	
Mechanical stokers	77	
	—	868
Carried forward		1,359
Depreciation.		
Railways and rolling stock	138	
Surface conveyors (not including belts)	150	
Mechanical haulages	23	
Mechanical stokers	130	
	—	441
Average monthly total		1,800
(*Annual Costs.*)		
Annual running and maintenance costs and depreciation		21,600

OLD PLANT.

Annual running and maintenance costs and depreciation, on basis of tonnage milled at present time	13,902
Annual increase in running and maintenance costs and depreciation, due to installation of labour-saving appliances on the new plant	7,698

The actual annual reduction in the working costs, due to the installation of labour-saving appliances, is, therefore, as shown in Table VI., £59,220, and is equivalent to a saving in the working costs of 2·99*s.* per ton milled.

TABLE VI.

	£
Decrease due to the reduction in the number of unskilled coloured labourers employed	54,918
Decrease in transport and off-loading costs	12,000
	66,918
Increase in running and maintenance costs and in depreciation	7,698
Annual decrease in the working costs, due to the installation of labour-saving appliances on the new plant	59,220

In order to reduce still further the number of unskilled coloured labourers employed underground, the author has under consideration at the present time a scheme which includes the lengthening of the "backs" from 200ft. to 400ft. and their equipment with stope conveyors of a maximum length of 448ft., and the installation of the mono-rail system of tramming in place of the ordinary tramway system at present in use underground. This system, suggested by the success of the mono-rail in connection with electric telpherage, consists, as the name implies, of a single rail suspended in the drive, crosscut, or winze by means of iron hangers firmly secured in holes drilled in the roof. Switches, turntables, crossings, &c., are easily adapted to the single rail. A switch, for example, consists simply of a short length of rail pivoted vertically at one end on the last hanger before the branch, and having the other end supported by a hanger sliding in a slot, curved to the arc of a circle having the pivot of the switch rail as centre and the rail itself as radius, cast in an iron plate secured horizontally to the roof of the drive. This permits just enough travel to allow the free end of the switch rail to swing from one branch to another, where it is secured by a sliding fish-plate.

The truck, consisting of the usual U or V-shaped body, is attached by a pin at each end to a bridle hung by means of two tee-shaped draw-bars to a pair of two-wheeled bogies running on the suspended rail. The short equal arms of the tee draw-bars have fixed axles on which the bogie wheels run loose, while the long arm of the tee is fitted with a swivelling clip connecting it to the bridle. The weight of the truck and of its contents and of the bridle is thus transmitted to the bogies through the swivelling clips of the draw-bars, and each bogie is therefore free to move independently of the other on a vertical axis. Since the wheel base of each bogie is as short as possible, and the bogies themselves are set as close together as clearance will allow, the trucks can negotiate with the greatest ease the very sharp curves on underground tramways.

The main advantage of the mono-rail over the ordinary system of hand-tramming along a two-rail track laid on the floor of the levels is that both rail and axle friction are reduced to a minimum, owing to the suspended rail and the bogie frames being above the stope box holes, and therefore out of the way of the dust and rock which, in the ordinary system of hand tramming, is inevitably spilled on the truck wheels and the track rails while the trucks are being filled at the box holes; and also out of the way of the acid water, mud, &c., which is nearly always present on underground tramways.

The capacity of the trucks ordinarily in use on underground tramways is 12 cubic feet, or half a ton each, and, owing to the bad working conditions, the number of men required to handle each truck is usually two, thus necessitating the employment of a large number of unskilled coloured labourers in tramming the ore from the stope boxes to the shafts. This number the author expects to reduce greatly by the installation of a carefully graded mono-rail system, and also by the introduction of an improved truck of 2 tons capacity, fitted with frictionless axle-boxes, on the design of which he is engaged at the present time. This truck will be capable of being easily handled by one man.

By the adoption of the above briefly outlined scheme the author hopes to bring down the number of unskilled coloured labourers employed in the actual handling of rock underground to what is practically an irreducible minimum. The only means by which the number could be further lowered, namely, an electric or compressed air railway system or other mechanical haulage system, whilst perfectly feasible in a coal mine or other mining proposition where the work is all carried out on one plane, is practically impossible under the conditions prevailing in the mines of the Witwatersrand, and, in fact, in metalliferous mining generally.

In conclusion, the author would particularly draw attention to the fact that the installation of the above described labour-saving devices, while greatly reducing the number of unskilled coloured labourers employed on the mine, has resulted in a very considerable increase in the number of skilled white men required.

THE INSTITUTION OF CIVIL ENGINEERS.

EXPERIMENTS ON WIND PRESSURE.

AT the ordinary meeting on Tuesday, December 3rd, Sir William Matthews, K.C.M.G., president, in the chair, the paper read was "Experiments on Wind Pressure," by T. E. Stanton, D.Sc., M. Inst. C.E. The following is an abstract of the communication:—

The experiments described in this paper form the second part of the research on the distribution and intensity of the pressure of the wind on structures, which was proposed by the committee of the National Physical Laboratory as the first investigation to be undertaken in the engineering department, and was commenced by the author in 1902.

The first part of this research, of which the results were communicated to the Institution in December, 1903, was the investigation of the resultant pressure and distribution of pressure on flat plates normal to and inclined to the direction of a uniform current of air.

As those experiments were made in a channel 24in. in diameter, the dimensions of the plates were necessarily small, but between the range in dimensions obtained, which for circular plates was from ¾in. to 2¾in. in diameter, the results indicated that the resistance of geometrically similar plates was proportional to the area of the plates. In the case of dissimilar plates, however, such as square plates and long rectangles, the resistances per unit area differed considerably.

The value of the resistance so found in these experiments on small plates was somewhat smaller than that determined by Dines, Frowde, and Langley for plates of the order of 1 square foot in area. For comparison, the values of the constant K in the pressure velocity relation,

$$P = K V^2,$$

are given in the following table:—

Experimenter.	Method.	Value of K.
Dines	Whirling table	·0029
Frowde	Moving carriage	·0037
Langley	Whirling table	·0083
Author	Plate in uniform current	·0027

On the completion of this part of the work, it was decided to make observations on flat surfaces of areas ranging up to 100 square feet when exposed to the wind, since general experience tended to show that in actual winds whose velocity was not uniform over time or space, the mean pressure per square foot on a large surface was considerably less than that on a small one. As a knowledge of this variation in resistance with the dimensions of the structure, if it exists, is all-important in design, the investigation of this problem was made the chief feature of the new experiments.

For the purpose of the work a steel windmill tower was erected in the grounds of the National Physical Laboratory at Teddington. The experimental boards and models of structures were attached to a light framework carried by the cap of the tower, the height of the centre of the boards from the ground being 50ft.

After some preliminary experiments, the method of observation finally adopted was the determination of the constant in the pressure-velocity relation for pressure-boards of varying dimensions and for the models of structures. It was found, as anticipated from a knowledge of the variable character of the velocity of the wind, that single observations were quite worthless for the purpose in view, but that, if for any pressure-board or model about 200 observations of the velocity of the wind and the corresponding pressure on the board were taken, it was possible to obtain a fairly accurate value of the constant. In these observations the velocity of the wind was estimated from a pair of pressure-tubes, similar to those used by Mr. Dines in his anemometer, placed about 15ft. above the centre of the board. These tubes were connected by lead pipes to a sensitive water gauge, of the type used in the author's previous experiments, placed at the foot of the tower. The resultant pressure of the wind on the board was estimated from a measurement of the pressure produced in a closed cylinder of air by the deformation of a thin steel diaphragm forming its cover, which was in contact with the centre of the pressure board. This pressure was also transmitted through lead pipes to the foot of the tower, and there measured by a similar tilting gauge to the one used for the velocity estimations. The simultaneous observations of pressure and velocity were only possible in the short periods of time in which the velocity of the wind was fairly constant. Such periods, lasting from two to five seconds, were found to occur about once a minute in a fairly steady breeze.

The results of these observations on three pressure boards, one 5ft. by 5ft., one 5ft. by 10ft., and one 10ft. by 10ft., gave practically identical values of the constant in the pressure velocity relation. In units of pounds per square foot and miles per hour the mean value of this constant for the three boards was 0·0032. As this value agreed so well with the average of those obtained by previous experimenters when using plates of the order of 1 square foot in area, it was not considered necessary to make experiments on plates smaller than the one 5ft. by 5ft. in the present case.

Further observations on the intensity of the pressure at the front and back of the boards appeared to show that the cause of the higher value of the constant compared with that obtained in the case of the small plates in the 24in. experimental channel, was the relatively greater intensity of the negative pressure at the back of the boards compared to that at the back of the small plates.

Experiments were also made on a model of a braced girder 29ft. long by 3ft. 7in. deep, and on a roof model whose sides were 8ft. by 7ft. The ratio of the resistance per unit of area of the model girder to that of a square board in the wind was found to be precisely the same as the ratio of the resistance per unit of area of a small model of the girder made to a linear scale of 1 in 42 to a square plate in the experimental channel and uniform current used in the previous experiments.

The resultant pressures on the roof were obtained, for both windward and leeward sides, at angles of 30, 45, and 60 deg. inclination to the horizontal, and indicated the considerable suction effects on the leeward side of a roof when the pressure inside the building is augmented from the windward side by open doors or windows.

These results lead to the conclusion that the resistance of a complicated structure in the wind can be accurately predicted from a determination of the resistance of a small model of the structure in an experimental channel.

PASS LIST, OCTOBER EXAMINATIONS, 1907.

Studentship (62).—W. Andrews, H. C. Ashworth, R. C. Atkinson, F. E. Baird, J. J. Barnes, A. C. Beard, P. Bergheim, J. J. Bevan, T. H. Bewlay, J. S. Bissett, E. C. Blake, M. G. Burton, C. P. Cæsar, B. H. Carreras, H. A. Chai, A. V. Cole, E. H. Collcutt, F. R. Court, K. S. Curtis, L. S. Deane, E. F. Edwards, D. A. Evans, P. N. Everett, F. S. De V. Gould, J. Greenhalgh, R. G. Hampson, W. Healey, E. S. Hector, J. E. Hobbs, F. Hodson, C. K. Imison, W. Ll. Jenkins, R. T. Jones, H. N. Lstherby, M. Macdonald, A. S. Marr, J. C. Matthew, E. Morgan, P. Naylor, P. I. Payne, S. Pearson, R. A. Pereira, W. A. Phillips, G. B. R. Pimm, A. C. Pratt, L. H. Richards, R. W. Richardson, H. D. Roberts, A. Searle, M. H. Shorto, E. L. Sladen, P. F. Spiller, W. S. Tait, J. A. Taylor, T. R. Terrell, W. H. Thompson, J. B. Thomson, L. P. Timmins, A. F. Tippett, T. M'C. White, F. W. Wonham, H. L. Wright.

Associate Membership (145): (*a*) *Candidates examined in London* (130): *Whole examination* (69).—C. W. Alexander, H. J. Amoore, W. Bailey, E. G. Beck, R. H. Blackburn, E. S. Bourne, F. E. Button, E. G. Carty, R. B. Chillingworth, C. S. D. Cole, J. C. Cooper, J. H. Dodd, P. Dougall, N. G. Dunbar, A. T. East, S. S. M. Ede, C. G. Eden, B. W. Elliott, J. R. Foulds, S. S. Frank, R. Gadsby, A. E. Gardener, E. R. George, H. C. Gill, C. W. Griffiths, W. A. Harris, J. Hassall, E. F. Heron, A. L. Higgins, F. S. Hildesheim, G. W. Hilliard, J. T. Hines, A. C. Howard, D. M. W. Hutchison, M. Jamieson, H. W. Lawson, A. Leighton, J. McClure, K. D. MacMillan, F. L. Macpherson, H. Milman, J. J. Murphy, O. T. Nettelton, R. Nicholls, P. M. Norris, H. R. B. Norrish, E. Oakden, T. W. W. Parker, R. Ratcliffe, J. M. Robertson, E. O. Rowley, W. C. Rubie, C. V. Sandeman, A. J. R. Scharenguivel, E. T. Schneider, M. H. Sears, F. V. Smith, F. G. Stevens, R. H. Streatfeild, G. S. Szlumper, S. H. Taylor, H. Terrell, M. S. Thompson, O. Thornycroft, W. T. Walker, J. Wharton, F. G. Whitley, P. Williams, A. R. Wright.

Section B of Part II. (36):—(*previously passed in Part I. and Section A of Part II.*).—A. E. Abbott, G. R. Allen, L. A. Baker, F. A. Barnes, G. B. Barton, G. W. M. Boycott, R. J. P. Briggs, P. P. Brown, D. W. Carter, F. L. Cook, M. K. Cooper-King, J. M. Cunningham, J. S. Diggle, A. S. W. Elder, F. G. Engholm, K. A. P. Field, P. T. Harrison, W. Henderson, jun., G. B. G. Hull, H. B. Jenkins, E. A. Lees, J. W. Liversedge, E. G. G. Matheson, S. O'Hara, E. O. Pearce, A. W. Pimm, C. P. Richards, D. C. Robertson, H. B. G. Robertson, L. J. Smith, L. E. Taylor, G. B. Thompson, H. C. Whitehead, H. C. Wildish, W. F. Williams, O. T. Wood.

Part I. and Section A of Part II. (25).—J. Bacon, jun., R. J. Baumgartner, G. H. Benton, A. C. Bousor, H. H. Bowack, H. G. Butchart, G. H. Carter, J. M. Cobb, H. A. Cox, G. H. Kay, C. Q. Keil, H. W. Lewin, E. G. L. Lovegrove, L. L. Mercer, E. W. Merrall, F. J. Payne, C. A. Pollock, C. L. W. Renton, F. H. Robinson, J. A. Royds, H. W. T. C. Sabine, F. E. Weekes, R. Weir, J. G. White, J. Wilde.

(*b*) *Candidates examined abroad* (15): *Whole examination* (14).—C. R. Barlow, C. L. Cox, E. W. M. George, A. T. Grant-Dalton, H. W. S. Husbands, B. T. Judah, H. K. Lamb, N. C. Percy, E. A. Royds, A. H. Smyth, W. W. K. Sparrow, E. F. Sykes, D. Tuck, A. G. Watson.

Part I and Section A of Part II. (1).—E. J. Stead.

POST-OFFICE ENGINEERING DEPARTMENT, LONDON.—The annual dinner in connection with this department will be held on Tuesday, February 18th, 1908, at the Grand Hotel, Trafalgar-square, W.C.

AUTOMATIC CAB-SIGNALLING ON LOCOMOTIVES.

On Thursday, the 5th inst., Mr. J. Pigg read before the Institution of Electrical Engineers a paper entitled "Automatic Cab-signalling on Locomotives." This paper dealt with an apparatus which has been designed by Mr. Vincent L. Raven, the chief assistant mechanical engineer of the North-Eastern Railway. The system employed is electrical, and the indications are taken into the cab by means of metallic brushes which pass over metallic bars fixed longitudinally on the line, though it is pointed out that this method of collection is not essential, since electro-magnets would produce a like effect without actual contact. Both visual and audible signals are employed, the visual signals being given by means of a miniature semaphore and of pointers, and the audible signals by means of a bell. The semaphore shows the condition of the line, and the pointers are route indicators. There is also a failure indicator by which the condition of the whole apparatus can be gauged. It would not be within the scope of the present article to describe the ingenious mechanism which has been brought together in the construction of this apparatus, but we may find space in a future issue to return to the subject. Meanwhile it will be sufficient to say that the condition of the signals ahead of him is notified to the driver in his cab. The signalman has no special control over the indications beyond the fact that he manipulates his signal levers in the ordinary way. The rest is done automatically. The driver has both bell and semaphore to inform him of the condition of the road in front of him, and, moreover, he has, in his route indicators, something to show whether the points are rightly placed for him in the direction that he has to go. He, like the signalman, has nothing to do with the working of the apparatus. All he has got to do is to watch it. The whole system has now been at work on the North-Eastern Railway during two winters on what is the fastest short-distance train in the world, and was and is, so Mr. Pigg tells us, working perfectly. Moreover, the directors of the North-Eastern Railway Company have arranged for the equipment of twenty more of their express engines, and of about fourteen miles of their main line between Newcastle and Durham.

The discussion which followed the paper would have been more valuable had there not been so many speakers with axes to grind. However, there was a good deal said that was of interest. Broadly speaking, the apparatus was attacked in three directions:—(1) Its complication; (2) its cost; and (3) the possibility of its breakdown. There was, however, a further and most important point which was raised by Mr. Jacomb Hood. There was, he said, no doubt that some such system was bound to come, but did it go far enough? Was it justifiable to spend a large sum of money simply to provide an apparatus which, after all, would only supplement existing signals? He thought, rather, that the direction in which advance would come would be that by which the work would be taken out of the driver's hands, and which would, if there were danger ahead, shut off the steam and apply the brakes. The apparatus is complicated, and we do not very well see how it could be otherwise, but apparently in spite of its complications it works well. In connection with the possibility of breakdown of, say, all the batteries employed, it was taken for granted by several speakers that a danger signal would not be given, but that the semaphore indicator would show a clear line. It was unfortunate that Mr. Pigg's reply was, owing to the late hour, curtailed, and that this point was not dealt with. It must be admitted, however, that in such an event as the breakdown of all the batteries it would appear that a danger signal is not given, as would have been anticipated.

It cannot be regarded as otherwise than hazardous that high-speed trains should be run in times of thick weather without any intimation to the driver of how matters are in front of him, and it is to be hoped that the many inventors now engaged on the work will find a solution.

The Great Western Railway on one of its branches uses a system by which audible signals of two kinds—whistle and bell—are given, and by means of which the distant signal has actually been done away with. This apparatus is said to give a danger signal if any or every part of it break down. There have been numbers of other proposals; none of them have really come to anything, or at any rate they are by no means universally employed. The only things that we can be sure about are that the whole matter is fraught with difficulty, and that a really efficient and cheap means of rendering accidents in fog and at other times impossible is most earnestly to be hoped for. Whether Mr. Raven's or the apparatus of the Great Western Railway or any other will fulfil all the necessary conditions time only can show.

MUSSOORIE HYDRO-ELECTRIC SCHEME.

An interesting function was performed on October 4th last, when the foundation stone of the new power-house for the hydro-electric scheme in progress at Mussoorie, Upper Punjaub, was laid in the presence of a distinguished company of military and civil residents. The stone was suspended from the centre of a structure resembling an old battlemented keep, beautifully decorated with evergreens and ferns, and emblazoned with the motto "Success to the Mussoorie Hydro-Electric Scheme," and the lowering tackle was so arranged that it could be set in motion by pulling a red, white and blue ribbon. Before this was done, however, an illuminated parchment scroll, signed by all present, was sealed and deposited, along with specimens of current coinage, local newspapers, &c., in a prepared cavity below the stone. The Hon. H. W. Reynolds, Commissioner for the Meerut Division, then spread the mortar with a silver trowel—a replica of the trowels used by native workmen—and lowered the stone into position. After an interlude for photographs, the company inspected the works. The primary object of the scheme is to provide a plentiful and reliable water supply for the "station." Springs which can be depended on for a quarter of a million gallons per day have been acquired by the municipality itself, but these are situated at a level of 1500ft. below Mussoorie itself, so that a pumping plant was required. Owing to the abundance of water-power in the district, a hydro-electric scheme was decided on, and the contract was awarded to Messrs. Bruce, Peebles and Co. about a year ago. A stream known as the Bhatta is being dammed, and a duplicate pipe line 4500ft. long runs down the hill to the power-house, supplying water to the three 300 horse-power Pelton wheels under 990ft. head. The pipe line and Pelton wheels were supplied by Messrs. James Gordon, of London, as sub-contractors to Bruce, Peebles and Co., Limited. Each Pelton wheel is direct coupled to a Peebles 150-kilowatt high-tension alternator, the combination running at 500 revolutions per minute. Current is to be transmitted at 6600 volts by two overhead transmission lines, one running to the pumping station direct, and the other to the town of Mussoorie, and then on to the pumping station, thus providing a loop system. The pumping station is being equipped with two 150 horse-power high-lift pumps each driven by a Peebles induction motor, and each unit being designed to carry out the whole work, the second being a stand-by. The remainder of the load which the station can carry will be furnished by public and private lighting and motor applications. The public lighting by means of arc lamps in the main streets and incandescent elsewhere is already arranged, and there appears to be no doubt that the remainder of the available power will early be taken up for private use. There is ample scope for further developments.

Past and Present Stratfordians' Annual Dinner.—The fourth annual reunion dinner of the past and present staff of the locomotive department of the Great Eastern Railway was held in the Abercorn rooms of the Liverpool-street Hotel, London, on Friday, December 6th, when a company numbering eighty sat down to dinner under the presidency of Mr. W. D. Craig, late chief draughtsman. The toast list was as follows:—"His Majesty the King," and "Her Majesty the Queen, T.R.H. the Prince and Princess of Wales, and the other members of the Royal Family," both proposed by the chairman; "Our Chairman," proposed by Mr. A. P. Parker, and responded to by the Chairman; "The Great Eastern Railway Company," proposed by Mr. W. Collingwood, and responded to by Mr. James Holden; "Old Stratfordians all over the World," proposed by Mr. J. H. B. Jenkins, and responded to by Mr. Godfrey Elliot; and "Present Stratford Men," proposed by Mr. F. D. Green, and responded to by Mr. A. W. Polley. Other speeches were made by Messrs. W. R. Preston and J. D. Twinberrow. Messrs. J. H. Adams, G. Macallan, A. W. Polley, W. Collingwood, A. J. Hill, and A. Glaze contributed to the musical programme. Mr. F. G. Perry acted as accompanist. The arrangements were made by a committee consisting of Messrs. J. Holden, chairman, Godfrey Elliot, A. J. Hill, J. W. Howard, W. F. Pettigrew, A. W. Polley, hon. secretary, and F. V. Russell.

The Home Secretary and Grinder's Consumption.—"It really looks," says the *Sheffield Telegraph*, "as if the Home Department of the Government mean to make a serious attempt to deal with the scourge known as grinder's consumption, a form of phthisis which is peculiarly rife in Sheffield, and which Dr. Scurfield, medical officer of health for the city, has succeeded in forcing upon the attention of the authorities in no uncertain way. A short time ago Dr. Whitelegge, Chief Inspector of Factories under the Home-office, and Mr. J. Cunningham, one of the under secretaries of the same department, held an important conference with the Sheffield Chamber of Commerce and the Cutlers' Company on the subject of 'Grindstone Dust,' and recently the Home Secretary, who has been taking considerable interest in the question, paid a private visit to Sheffield for the express purpose of familiarising himself with local conditions, in view, we understand, of legislative action. In company with Mr. J. H. Rogers, Chief Inspector of Factories in Sheffield, he visited several works in the city, and saw the disease 'in the making,' as well as having improved methods of dust prevention in the grinding trades demonstrated to him. Two noteworthy methods which have commanded attention as the result of an investigation carried out by Dr. Whitelegge are (1) a wet method of 'racing' grindstones when first hung; and (2) an improved form of hood for catching dust, &c., given off in the process of dry grinding."

West of Scotland Iron and Steel Institute.—The annual dinner of this body was held in the Grosvenor Restaurant, Glasgow, on the 7th inst., when Mr. T. B. Rogerson presided over a company of about 300. Rear-Admiral Bearcroft, in responding to "The Imperial Forces," said that the complicated machinery which went to the making of a modern man-of-war had increased very considerably the demand for scientific education, but at the same time the science that was required must, when real business was in hand, depend a great deal upon "the man behind the gun." Reference had been made to the improvement in gunnery, which had been so marked in the last year or two, and he had no hesitation in saying that that improvement was due to the initiative and energy of a very distinguished officer, Sir Percy Scott. The definite decision to proceed with the naval base and dockyard at Rosyth, and the establishment of a torpedo factory at Greenock, and a torpedo testing range in Loch Long, all pointed to increased efforts for the efficient working of the forces of the country. The toast of "The West of Scotland Iron and Steel Institute" was proposed by Mr. W. Mitchell Thomson, M.P., who said that in Glasgow they were in the cradle of the Scottish national iron and steel industry, and it was a happy combination which united science and commerce, and both with social reunion. The institute showed increasing and continued vitality. Founded in 1889, in its first year it had 169 members; now it had a membership of 427. Last year 56 new members were enrolled, and this year already 28 had been added. The chairman, in reply, said that the West of Scotland Iron and Steel Institute was, after the Iron and Steel Institute of Great Britain, the largest metallurgical society in Great Britain. They had added twelve more members since the figures were given to Mr. Mitchell-Thomson. As an institute they were endeavouring to obtain members who would give their thoughts each to the other, and thereby help the iron and steel industry generally. Reference had been made to legislation to broaden the basis of the trade, and while not desiring to enter upon politics, he firmly believed that legislation would broaden the foundation of the trade and be influential in increasing its prosperity. It seemed very hard—they were suffering from a depression especially in the steel trade—that most of the steel works were working "slack time," not at their full capacity, and yet steel and iron goods were being imported from countries where they were protecting themselves. That was a political point. Some members might be with him, others might be against him. It was a question on which they wished to convince those against them to come with them and be of them. Replying to the toast of "The University and Educational Interests of the West of Scotland." Principal MacAlister first paid a high compliment to the department of engineering ably presided over by Professor Archibald Barr, and afterwards referred to the establishment for the first time on an independent footing of a lectureship in metallurgic chemistry, which, he said, showed that they in the University realised that the scientific foundations were their peculiar business, and that those which chiefly related to the industry were those of which they should take the greatest care, and support and encourage in every way in their power.

CATALOGUES.

Andre Citroen and Co., 19-21, Queen Victoria-street, E.C.—A small pamphlet which has been sent to us by this firm deals with spur and bevel gears, and with single, double, and multiple cut helical teeth.

A. Borsig (London agent, Robert Weatherburn, Finsbury pavement House, E.C.).—This is a circular giving particulars of locomotives for all industrial purposes. A table is given showing the sizes of locomotives which the firm keeps in stock.

Allis-Chalmers Company, Air Brake Department, Milwaukee, Wisconsin, U.S.A.—Two bulletins, Nos. 1514 and 1515, to hand from this firm deal with the "O.B." pneumatic governor and the "J" emergency valve respectively. Both these are air brake accessories.

Contracts.—In connection with the important extensions now proceeding at their Knostrop sewage works, the Leeds Corporation has placed an order for a large weighbridge with the firm of Samuel Denison and Son, Limited, of the Hunslet Foundry, Leeds. This weighbridge is to be constructed for a great diversity of traffic, for ordinary railway wagons on standard gauge of 4ft. 8½in., for tramway trucks to a gauge of 24in., for road traction engines, motor wagons, and ordinary carts and drays.

An Area Scale.—We have received from Messrs. Casella and Co., of 11-15, Rochester-row, Victoria-street, S.W., an area computing scale which is extremely simple to use, and sufficiently accurate for most practical calculations. The instrument, which is called the White-Bean Area Scale, consists of a clear transparent piece of celluloid, 7in. long by 6½in. broad, its thickness only being about $\frac{1}{75}$in. There is a number of vertical lines printed on the face of the celluloid from a specially prepared block, the lines being equidistant and alternately full and dotted. To find the required area of a figure all that has to be done is to place the scale over the figure to be measured, and either the length of the full line ordinates, or the dotted ones are then marked off on the edge of a piece of paper, or determined with a rule. The resultant length is then measured off on one of the two scales printed on the celluloid, and the half the area is obtained either in square centimetres or square inches. This is multiplied by two. When more accurate results are required, all the ordinates, both dotted and full lines, within the boundary of the figure are measured, and the area is then given on the scale direct, without any further multiplication. This is the simplest method of finding the area of an irregular figure that has yet been brought to our notice, and besides being cheap the scale is also of a convenient size.

Royal Commission on Canals and Waterways.—The Royal Commission on Canals and Waterways have recently obtained Treasury sanction for an inquiry into the probable cost of improving the canals and waterways connecting the Midlands with the Thames and the Humber. Unless the results of this inquiry lead the Commission to reconsider their scheme, the investigation as to cost will not stop with these two routes, but will extend to two more, viz., those connecting the Midlands with the mouths of the Mersey and the Severn. Sir John Wolfe Barry and Partners have undertaken the investigation on behalf of the Commission, and will shortly inspect, first the route from Brentford to Birmingham, *viâ* the Grand Junction, Oxford and Warwick Canals, and secondly the route from Norton Junction on the Grand Junction Canal, *viâ* the Leicester and Loughborough Navigations, through Nottingham, and by the river Trent to the Humber. The improvement of the Regent's Canal in connection with the route to the Thames will be reported upon. The estimates as regards canals will be for two or three alternative gauges, of which the smallest will be a canal with locks capable of accommodating not only barges carrying 100 tons, but also multiples of smaller canal boats. In the case of rivers, the cost of improving them so as to be navigated by barges and sea-going lighters of still larger capacity will be studied. Meanwhile, for some time, a committee of the Commission has been collecting the necessary information as regards the water supply available for such improved inland navigations.

Society of Engineers.—It was announced at the fifty-third annual general meeting of the Society of Engineers, held on Monday, that the following premiums had been awarded by the Council for papers read during the past session, viz.:—The President's gold medal to Mr. R. W. A. Brewer for his paper on "Liquid Fuels for Internal-combustion Engines." The Bessemer premium of books to Mr. E. J. Stead for his paper on "The Connaught Bridge, Natal;" a Society's premium of books to Mr. C. A. St. George Moore for his paper on "Working Experiences with Large Gas Engines;" and a Society's premium of books to Mr. H. Blake Thomas for his paper on "Subaqueous Operations." Mr. Joseph William Wilson, M. Inst. C.E., was elected president for the ensuing session. The fifty-third annual dinner of the Society of Engineers was held on Wednesday evening at the Hotel Cecil. The dinner was well attended, and amongst those present we noticed the president-elect, Mr. Joseph William Wilson, M. Inst. C.E., Sir William Mathews, K.C.M.G., Sir Edward Rabon, C.B., R.E., Sir Alexander Binnie, Dr. Rideal, Capt. Riall Sankey, and Mr. Twelvetrees. In responding to the toast of the Society, Mr. Wilson referred to the progress which had been made during the past year, and stated that the membership now numbered over 550. Reference was made to the loss the Society had sustained through the death of its late secretary, Mr. Perry F. Nursey, who had been so long connected with and done so much for the Society. It is not generally known that this was the first institution of its kind to organise visits to works for its members, as such was the case, according to the chairman. A musical entertainment was given during the evening, which was greatly appreciated by those present, and added to the enjoyment of the evening.

Oil Fuel or Electrical Traction in Italy.—Oil fuel, which is being introduced upon some of the Italian railways, promises to supplant the schemes for electrifying main lines, which have already been in abeyance for a number of years. On account of the ventilating difficulty it was proposed to extend electrical traction from purely local and suburban lines, in the neighbourhood of Milan and in the Lombardy rural districts, to those portions of main lines which have tunnels of three and four miles in length, constructed with steep gradients necessitating considerable combustion of coal in the ascent of trains. The electrical equipment of the Giovi tunnel on the local and through goods line between the villages of Pontedecimo and Bussalla—about six miles—is the first important step towards the electrification of Italian main lines, properly so called, but it is thought that other projects, such as the electrification of the Mount Cenis tunnel and of the Apennine tunnels north of Pistoja, which would have involved a cost of 12 million lire, may not be carried out, for we understand that trials of a new form of naphtha burning locomotive, recently constructed, have been so signally successful on the whole line between Bussoleno and Modane—including the Mount Cenis tunnel—that it is intended also to carry out trials on the line between Pistoja and Porreta on the Florence-Bologna line, in order to see if by locomotives of this type the heavy cost of electrical installation may be avoided. Analyses of the air in the Mount Cenis tunnel, made by the State Railway's chemists, are said to have shown an almost complete absence of any deleterious substances during the periods of heaviest traffic through the tunnel when these locomotives were at work. It is said that there is no smoke whatever, and that one of the new locomotives easily accomplishes the work of three locomotives as previously employed. The new locomotives burn both naphtha petroleum and coal, and are remarkably economical with the latter. Fourteen are at work, and more are on order of the same type to increase the working capacity of the line.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Continental Inquiries.

THE market this week is quiet, but no worse than it was last week; indeed, if anything, rather more cheerfulness is apparent since inquiries have been received on German account for pig iron, and if these should result in orders the quantity needed is likely to be considerable. Very low figures are, however, spoken of, so that it remains to be seen whether it is worth the while of Midland makers to close. Staffordshire cinder forge is quoted 55s.; part-mine, 57s. to 58s.; best all-mine, 87s. 6d. to 92s. 6d.; and cold blast, 115s. Good outputs are being made of Northamptonshires at 54s. to 55s., and of Derbyshires at 56s. to 57s. Foundry sorts continue scarce and dear. It is thought by some authorities that matters may improve in the early spring. Stocks are low in all departments.

Manufactured Iron.

Marked bars are in good call at £9 for engineering purposes, and considerable quantities of unmarked bars are also being turned out at from £7 2s. 6d. to £7 7s. 6d. Galvanised corrugated sheets are quoted £13 2s. 6d. for 24 gauge. The November shipments declined from 43,931 tons last year to 37,071 tons this year, a large increase with India having failed to make up for only stationary trade with Australia, and for declines with Japan, Chili and the Argentine Republic. The corresponding drop in value was from £605,529 in November, 1906, to £536,922 last month. With regard, however, to the shipments for the first eleven months of each year, there has been a welcome improvement in quantity from 405 697 tons to 440,885 tons, and in value from £5,383,371 to £6,474,683, the chief increases having been with India, Australia, New Zealand and Japan. Plain black sheets (doubles) this week are quoted £8 2s. 6d. to £8 7s. 6d.

Steel.

Local makers of steel are expressing satisfaction that the Welsh tin-plate manufacturers have not accepted the overtures of the American semi-finished steel makers to purchase large quantities of the latter material at high prices. It is felt that there is quite sufficient American competition in steel already, without this phase being further emphasised. Bessemer billets are quoted this week £5 7s. 6d., and Siemens £5 10s. Angles are £6 15s. to £7, and girder plates £7 5s. to £7 15s.

The Tube Trade.

The tube trade is fairly active. Further particulars are awaited with interest as to the alleged fresh international agreement. This very old question of international competition and how best to meet it is almost a "hardy annual" and has always been found hitherto very difficult to adjust; but it would appear that some definite understanding has at last been arrived at. How long it will be kept to is the question now being discussed. With regard to material for tube making, gas tube strip is quoted at date £7 10s. to £7 12s. 6d.

The Engineering Trades.

The engineering trades are fairly active, a well situated branch being the railway carriage and wagon building trade, which has some good foreign orders on hand. Gas and oil engine builders are busy, and so also are some of the electrical engineers, and also hydraulic machinery makers. Mechanical engineers report well as to the demand for lathes and other shop tools.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Wednesday.

Gloomy Future for Pig Iron.

THE attendance on the Manchester Iron 'Change on Tuesday was quite up to the average. It could not be said, however, that business in pig iron was commensurate with the attendance. Inquiries showed that opinions were divided as to the future. It was admitted that in many instances there was a scarcity of prompt iron, especially Scotch. For forward delivery, however, there was some holding back, and, although shipments continue to decrease on the East Coast, there was some improvement to note in Middlesbrough brands. Derbyshire and Staffordshire have also apparently reached the extent of the downward limit, and agents and merchants were asking the full rates of the day, though, from a buyer's standpoint, these were more or less variable. The problem of the future was the absorbing topic. Lincolnshire is practically off the market here, except at prices which will bring it into line with Derbyshire and similar makes, and of this there does not seem much prospect. Scotch is extremely scarce, except for far forward delivery, and there is no call for hematite except, perhaps, for mixing purposes. There appears to be an effort on the part of many merchants to cover engagements made some months ago, and this somewhat complicates the position. Still they are, as far as possible, following the example of consumers, and playing a waiting game. On the whole, events point to a reduction in new contracts early on in the year.

Finished Iron.

Very dull, and while there is no change to report orders are by no means abundant.

Steel.

There is a very moderate business passing in most departments. It was reported that considerable business was being done in foreign billets other than German at lower prices than last week.

Copper.

There is practically no change to report in manufactured stuff.

Lead.

Following the slump in pig lead, sheet has receded to some extent, but there still seems to be a margin for further reduction in manufactured stuff.

Quotations.

Pig iron: Lincolnshire No. 3 foundry, official, 57s. 6d.; Staffordshire, 56s. 6d. to 57s. 6d.; Derbyshire, 56s. to 57s.; Middlesbrough, open brands, 58s. 4d. Scotch: Gartsherrie, 67s. 9d.; Glengarnock, 68s.; Eglinton, 64s. 9d.; Dalmellington, 64s. 3d., delivered Manchester. West Coast hematite, 67s. 6d.; East Coast ditto, 69s., both f.o.t. Scotch, delivered Heysham: Gartsherrie, 65s. 6d.; Glengarnock, 65s. 9d.; Eglinton, 62s. 6d.; Dalmellington, 62s. Delivered Preston: Gartsherrie, 66s. 9d.; Glengarnock, 67s; Eglinton, 63s. 9d.; Dalmellington, 63s. 3d. Finished iron: Bars, £7 10s.; hoops, £8 2s. 6d.; sheets, £8 5s. Steel: Bars, £7 5s.; hoops, £8 2s. 6d.; sheets, £8 15s.; boiler plates, £8 12s. 6d.; plates for tank, girder, and bridge work, £7; English billets, £5 5s. to £5 10s.; foreign ditto, £4 15s. to £4 17s. 6d. Copper: Sheets, £80; tough ingot, £68; best selected, £67 10s. per ton; copper tubes, 10½d.; brass tubes, 8½d.; condenser, 9½d.; rolled brass, 7½d.; brass wire, 7½d.; brass turning rods, 7d.; yellow metal, 7½d. per lb. Sheet lead, £18 17s. 6d. per ton. English tin ingot, £136 per ton.

Lancashire Coal Trade.

Trade on spot is somewhat quiet. There was a good attendance on the Coal Exchange on Tuesday, but the better qualities of house coal were rather neglected. Lower grades, however, were in fair inquiry, and owing to the settlement of the cotton dispute, slack and other sorts of steam coal are in good request. The demand on shipping account is also steady. There is no change in the official rates of Lancashire coal, but offers from outside sources are more numerous, and buyers are filling their requirements for them as far as possible.

BARROW-IN-FURNESS, Thursday.

Hematites.

A slow business is being done in hematite iron. The transactions of the week have been few in number and of small aggregate bulk. Both the prompt and the forward demand is quiet, and buyers are in their present transactions only covering their immediate requirements. With a tendency in the direction of an even quieter state of things, and with the prospect of still lower values ruling before long, forward business is being neglected. Makers are therefore short of orders, and much of what they are doing is on the hand-to-mouth principle. Makers have reduced their prices this week for mixed Bessemer numbers to 68s. net f.o.b., and warrant iron sellers are at 67s. 7½d. net cash, buyers not quoting, while forward sales are at 66s. It is anticipated before the close of the year that still lower quotations will rule. Stocks of iron have been reduced by a small parcel during the week, and now stand at 6119 tons, or not one-tenth the weight at which they bulked at the beginning of the year. Very few sales are noted of special hematites, and a smaller business is being done in ferro-manganese and spiegeleisen. Charcoal iron is in good demand, and there have been some sales of scrap iron. Iron ore is weaker alike in demand and in price. Good average native sorts are being sold at 13s. 6d. net at mines.

Steel.

There is a very quiet demand for all the classes of steel made in this district. The mills at Barrow have this week been on full time on plates, on half time on rails, and the merchant mills have been at a standstill. The demand for rails is exceptionally quiet, very little is being done in shipbuilding material, while the market for merchant classes is almost nil. Prices are easier, with heavy rails at £6 2s. 6d. net f.o.b; and ship plates heavy, at £7 5s. net cash. A better demand for shipbuilding material and for heavy steel castings is expected with the turn of the new year.

Shipbuilding and Engineering.

It is generally understood that the battleship Rodney, which the Admiralty are giving out to private builders, will be placed with Vickers, Sons and Maxim. Engineers have booked new and important orders, and are very busy.

Shipping and Coal.

The exports of iron last week from West Coast ports were 5134 tons, and of steel 7854 tons, a total of 12,988 tons, being an increase of 3924 tons on the corresponding week of last year. The aggregate shipments this year to date have reached 798,345 tons, an increase on the corresponding period of last year of 32,072 tons. Coal and coke are again lower in price.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The General Position.

IN the coalfield the activity which has now been marked so long is maintained, the only weakening being in respect of the call for domestic fuel, owing to the continued open weather, and that weakening has not been distinct enough to modify quotations. An excellent business is being done in steam coal for all markets, and trade with Hull, as will be seen from figures given in another paragraph, has been exceedingly large during last month, and, indeed, for the completed period of the year. In the iron market, a little more is being done for delivery early next year. Derbyshire foundry and forge are again quoted 1s. per ton lower. The heavy industries are unchanged on the week. Fresh orders for military and marine material are still waited for, but at the time of writing we hear of nothing new in these departments. The lighter trades remain as already noted.

Coal Trade with Hull.

The figures exhibiting the weight of coal taken to Hull for November, and showing the business done with the great Yorkshire port for the eleven months, have just been issued. For the month the weight is 578,208 tons, against 492,224 tons for November of last year; for the eleven months, 6,059,088 tons, against 4,650,400 tons in the corresponding period of 1906. There is thus an increase, as compared with last year, of 85,984 tons for the month, and of 1,408,688 tons for the eleven months. These figures bring out very forcibly the remarkable expansion which has characterised the Hull coal trade. The largest contributing collieries were, as usual, Denaby and Cadeby Main, which sent 44,440 tons during last month, and during the eleven months 585,904 tons. Aldwarke Main comes next with 27,144 tons for the month, and 227,920 tons for the eleven months.

The Coastwise Traffic.

The leading feature in the coastwise traffic from Hull is the fact that it has now, during the eleven months just completed exceeded a million tons, the actual figures being 1,160,234 tons, of which no less than 1,004,050 tons were despatched to London, 33,553 tons to Plymouth, and 21,175 tons to Gravesend. The weight sent coastwise last month was 120,070 tons, of which 111,718 tons went to London. This coastwise traffic is largely made up of heavy purchases of gas-coal from Yorkshire by metropolitan gas companies.

Brisk Export Coal Trade from Hull.

Very heavy business has been done from Hull with foreign markets during the eleven months. For November the total is 301,300 tons, which compares with 223,537 tons for November of 1906. These figures bring up the export trade to 3,151,482 tons for the completed period of the year, against 2,300,747 tons for the eleven months of 1906. The German business for the month is nearly double that of November of last year—68,229 tons, compared with 34,945 tons. Sweden comes next with 62,033 tons, compared with 48,260 tons; Holland third, with 42,965 tons, compared with 21,065 tons, and North Russia fourth, with 42,245 tons, compared with 36,529 tons. For the eleven months the German market took 480,836 tons, against 238,041 tons in the corresponding period of 1906. A still greater advance was shown by Holland, which took 749,256 tons, against 240,782 tons. North Russia received 457,957 tons, against 509,548 tons, and Sweden 377,025 tons, against 383,411 tons.

Coke, Coking Slack, &c.

Coke remains at the lower figures quoted last week, 13s. to 14s. per ton for best washed, and 12s. to 13s. per ton for unwashed. Slacks for steam-producing purposes are firmer and rather higher, best qualities now fetching 7s. to 7s. 6d. per ton, secondary grades from 6s. to 7s. per ton. Manufacturing fuel, for furnaces, 10s. to 12s. per ton.

Hematites.

West Coast from 86s. 6d. to 88s. 6d. per ton; East Coast from 82s. 6d. to 84s. 6d. per ton, both delivered in Sheffield and Rotherham; East Coast subject to 2½ per cent. Hematites are offered for forward delivery at 1s. a ton less, but while there is a disposition to sell, there seems little or none to buy.

Iron and Steel.

The reduced quotations we gave last week for Lincolnshire irons still holds as follows:—No. 3 foundry, 55s. 6d. per ton; No. 4 foundry, 55s. per ton; No. 4 forge, 54s. 6d. per ton; No. 5, mottled, white, and basic, 55s. 6d. per ton. At these rates some extra business has been done, mainly for immediate or early requirements, and a little for delivery early in the New Year. Derbyshire No. 3 foundry and No. 4 forge have again been reduced 1s. a ton each, current quotations being now 57s. a ton for foundry, and 55s. a ton for forge. There are practically no stocks of pig iron, and makers are being pressed for deliveries. Some additional business, as we mentioned last week, is being done on forward account, but not, so far as we can hear, in any great quantities. There is no change to report in the steel departments, the volume of fresh work not being so large as could be wished. In some directions, and mainly in the lighter steel branches, the reports are fairly satisfactory; but it is improbable that any alteration of consequence will take place this year.

Railway Material.

A good business continues to be done on colonial and foreign account; but we are informed that the weight of new work is not equal to what it has been during the last few weeks. This may, however, be only temporary, and occasioned by the near approach of holidays. Many engineering firms take stock at the New Year, and are not therefore desirous of having goods in stock which are not to be immediately used.

Cutlery Exports.

The steady improvement noted in the trade done with district markets during the year was maintained last month, the value of exports having been £66,308, as compared with £65,966 for November of 1906. For the eleven months the value was £710,859, against £651,342 for the corresponding period of 1906. The increasing markets on the month are Norway, Belgium, France, Spain and Canaries, British East Indies, Australia, Canada, and the markets grouped under "other countries." The decreasing markets on the month were Russia, Germany, Netherlands, United States, Chili, Brazil, Argentine Republic, British South Africa, and New Zealand. Sweden and Cuba for the month are both entered on the return as nil, compared with £158 and £224 respectively for November of last year. Australia heads the list with trading for the month, amounting to £10,535, compared with £9868 for November of last year; for the eleven months £125,216, compared with £100,420 for the eleven months of 1906. Canada comes next with £9291 for the month and £102,221 for the eleven months, compared with £8461 and £84,345 respectively for the month and eleven months of 1906.

NORTH OF ENGLAND.

(From our own Correspondent.)

Reducing Pig Iron Production.

THE usual concomitants of a depression in trade are becoming generally noticeable, among them more particularly being a decuming production of nearly all descriptions of iron and steel, though as yet there is not to be recorded increasing stocks, for the Cleveland pig iron makers are taking precautions not to have stocks accumulating. They have learnt wisdom from the experiences of the years 1904 and 1905, when the stock of Cleveland pig iron in the public stores ran up from 78,000 tons to 750,000 tons. But for that heavy stock they would have done much better during the recent periods of prosperity in respect to prices. It was the existence of the immense stock in Connal's that kept quotations from going up considerably more than had to be recorded, and warrants have competed with makers' iron very keenly. Producers are, therefore, meeting the lessened demand by blowing out furnaces, and next year there will be fewer furnaces in operation by a good deal than has been reported this year. In the North-East of England 91 furnaces have been in blast this year, out of 116 built, but by the end of this month the number at work will not be more than 79, and probably only 77. It has already been reported in this column that five furnaces were blown out in October and November in this district. The consumption of coke has fallen off considerably, and prices have dropped with some rapidity—in fact, supplies can be got at 16s. per ton for delivery at Middlesbrough furnaces from sellers who in October were asking 22s. 6d., and who have had their price this year up as high as 25s.

Cleveland Pig Iron.

Business in Cleveland pig iron is almost at a standstill; consumers appear to have enough to go on with, and expecting further reductions in prices, will not purchase for forward delivery. This is not a season when an improvement in trade is likely to set in, and generally the tone of the market is the reverse of encouraging. It is at least four years since business was so slack, and traders seem to have made up their minds that things will be worse before they are better. This week pig iron of all kinds, Rubio ore, and coke have all fallen in price, but consumers lack confidence, and are not to be tempted by the reductions that are made in quotations, especially when such unsatisfactory reports are coming from all parts, both at home and abroad, about the poor condition of trade. The excellent Board of Trade returns, the good shipments, and the still decreasing stocks are quite without influence; they represent business done in the past, and afford no criterion of the future. No. 3 Cleveland G.M.B. pig iron has mostly been quoted this week for prompt f.o.b. delivery at 50s. per ton, but 49s. 6d. is the latest price, while No. 1, which has been 6s. 6d. per ton dearer than No. 3, is now at 53s. 6d., and the difference between it and No. 3 is likely to be less, as the Northern shipping season is now practically over. No. 4 foundry is at 49s., and No. 4 forge at 48s. 6d. All the lower qualities are scarce—indeed, mottled and white can hardly be got at all.

Hematite Pig Iron.

There is a complete slump this week in the prices of East Coast hematite pig iron, notwithstanding that the make has been reduced considerably, but the prospects of those who are the chief consumers of hematite pig iron are very indifferent, and almost everyone expects to see hematite down to the usual 10s. per ton above No. 3 Cleveland G.M.B. pig iron. There has been a difference this year of as much as 24s. The present price of mixed numbers of East Coast hematite pig iron is 66s. per ton, which is 16s. 6d. below the top price of the current year. Rubio ore has fallen this week to 16s. 6d. per ton for delivery at wharf on Tees or Tyne, that being 8s. 6d. per ton below the year's best, and some business has been done at 16s. 4½d. Consumers have no difficulty in buying at 16s. 6d., or 1s. below last week's price.

Pig Iron Stocks.

Probably the only good feature of the trade at the present time is the continued decrease in the stock of Cleveland pig iron in Connal's public stores. Considering that depression is generally reported, and that shipments are falling off, it is unexpected to find that there is still a drain on Connal's store, the stock having fallen to 87,679 tons, or 8202 tons this month. The stock consists of 79,920 tons of No. 3 Cleveland, and 7759 tons of other Cleveland iron deliverable as standard.

Pig Iron Exports.

Shipments of pig iron from the Cleveland district are falling off, and are the worst of any month this year. They are poor to Germany and are likely to be less, as that country can meet her own requirements now. This week the Luxemburg ironmasters have reduced the price of pig iron 10s. per ton, making the figure 54s. per ton, which puts British pig iron "out of court" in the Rhine district, burdened as it is with a 10s. per ton duty, and a longer carriage. The total shipments from this Cleveland district this month have reached only 35,078 tons against 52,223 tons last month, 48,064 tons in December, 1906, and 33,112 tons in December, 1905, all to 11th. It is not likely that there will be any material improvement till March in the exports of pig iron.

Manufactured Iron and Steel.

A marked slackening is reported in most branches of the finished iron and steel industries, and everything points to a quiet winter. Several of the works are badly employed now, and are likely to continue so until a revival appears in shipbuilding, of which there is no immediate prospect. No changes in prices can be reported this week.

Coal and Coke.

The coal trade is sharing in the depression that has overshadowed the iron and steel industries, but it is not affected to anything like the same extent, and there seems to be no lack of work at the collieries. The foreign demand, which has been extraordinary all the year, has become decidedly quieter, and it seems certain that the shipments, hitherto this year the best on record, will shortly taper off considerably. It could hardly be expected that such an extraordinarily brisk trade would continue for long. Best steam coals are at 15s. 3d. per ton f.o.b.; best gas coals, 13s. 3d.; seconds gas, 12s. 9d.; and coking coal, 12s. 3d. Coke has declined in value rather quickly this week, and most sellers would accept 16s. per ton for furnace coke delivered at the Middlesbrough works, or 9s. per ton below the maximum of the year. The slackening of demand has led to the stoppage of a large number of ovens in the county of Durham, and the situation has changed, in that sellers are now seeking out buyers; all the year it has been the other way.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General State of Trade.

THERE are as yet no indications of an improvement in trade generally, and, indeed, there are few individual branches of industry that show any tendency in that direction. A portion of the activity noticeable in a few connections is ascribed to the desirability of having orders completed before the end of the year. But of fresh business there is an almost universal scarcity. The general opinion is that as values have been too high a revival of business can hardly be expected until costs of production shall have been lowered still further all round.

The Warrant Market.

Despite the fact that warrants in circulation are greatly reduced compared with their number some time ago, the bulk of the transactions in the warrant market is declared to be of a purely speculative nature. Rumours as to the impending blowing out of furnaces in the North of England were used as a lever to improve values towards the end of last week, but the improvement of 6d. a ton in Cleveland warrants which resulted in these reports was subsequently lost. It is recognised that as no business can be looked for from America, and the Continent being now competitors rather than buyers, the current output of pig iron ought to be more than sufficient to meet all requirements. Business has been done in Cleveland warrants from 49s. 3d. to 50s., and back to 49s. 6d. cash, from 49s. 6½d. to 49s. one month, and 49s. 6½d. to 48s. 6d. for delivery in three months. Scotch warrants are at 59s., Cumberland hematite 67s. 7½d., and standard foundry iron 48s. 6d. per ton.

Scotch Makers' Pig Iron.

An additional furnace has, since last report, been put in blast at Wishaw Ironworks. There are now 41 making hematite, 39 ordinary, and 6 basic iron, the total of 86 furnaces thus in operation in Scotland comparing with 85 last week and 89 in the corresponding week of 1906. The current demand is comparatively light as regards fresh work, but makers have still considerable quantities of iron to turn out under former contracts. Prices of makers' iron are again in a number of instances lower, the reduction varying from 6d. to 2s. per ton. G.M.B., No. 1, is quoted at Glasgow, 63s. 6d.; No. 3, 60s. 6d.; Carnbroe, No. 1, 65s.; No. 3, 61s.; Clyde, No. 1, 67s. 6d.; No. 3, 62s. 6d.; Gartsherrie, No. 1, 68s.; No. 3, 63s.; Calder, No. 1, 69s.; No. 3, 63s.; Summerlee, No. 1, 71s.; No. 3, 63s.; Langloan, No. 1, 75s.; No. 3, 70s.; Coltness, No. 1, 90s.; No. 3, 68s.; Glengarnock, at Ardrossan, No. 1, 70s.; No. 3, 65s.; Eglinton, at Ardrossan or Troon, No. 1, 63s.; No. 3, 60s. 6d.; Dalmellington, at Ayr, No. 1, 65s.; No. 3, 60s.; Shotts, at Leith, No. 1, 69s.; No. 3, 64s.; Carron, at Grangemouth, No. 1, 73s.; No. 3, 65s. per ton. The demand for Scotch hematite has been contracting, as has also its price, merchants now quoting 72s. 6d. per ton for delivery at the West of Scotland steel works.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week amounted to 5425 tons, against 11,071 in the corresponding week of last year. To Italy there was despatched 320 tons, Germany 245, India 807, United States 2/3, Canada 65, South America 50, Australia 50, France 20, Holland 160, Belgium 40, China and Japan 85, other countries 149, the coastwise shipments being 3161, compared with 2555 in the corresponding week of 1906. The arrivals of Cleveland pig iron at Grangemouth were 9376, against 9622 in the corresponding week, showing a decrease of 246 tons, but there is a total increase in these imports since the beginning of the year amounting to 16,360 tons.

Finished Iron and Steel.

These important trades so far show no material improvement. In the steel trade there has in the last few days been no lack of inquiry, but very little actual business appears to have been done, these facts suggesting that possible buyers are feeling their way, but have not yet been able to arrange matters so as actually to give out orders. The impression is pretty general that business is not unlikely to continue dull until after the turn of the year. Makers of manufactured iron have difficulty in keeping their works going anything like full time.

The Tube Trade.

It is not yet quite apparent to what extent the tube trade may benefit from the international agreement that has been carried through at Paris. The Scotch makers are reported to have raised prices considerably by the reduction of discounts, and it is said that they will not now quote f.o.b. at Glasgow, but only cost, freight, and insurance (c.i.f.), and will require of buyers that they will disclose their markets.

Proposed Reduction of Shipyard Workers' Wages.

A few days ago the Clyde Shipbuilding and Engineering Employers intimated that they propose, immediately after the New Year holidays, to reduce wages by 5 per cent. on piece rates and 1s. per week on time rates of pay. The reduction will apply to boilermakers, mechanics, and all other ironworkers in the shipyards and boilershops; to all engineers, mechanics, and others in the engine shops; to the shipwrights, the joiners, and practically all journeymen workers of whatever class. The matter was considered on Monday evening, at a meeting in Glasgow of the Clyde District Committee of the Federation of Engineering and Shipbuilding Trades, when a resolution was adopted expressing the opinion that the reduction in wages is unwarranted, and declaring that they "will resist it to the utmost of their ability."

The Coal Trade.

The colliers recently made a demand for a further increase of 9d. per day in their wage; the employers offered 3d., which the men's representatives rejected, but the arbiter, Lord Ardwall, has made an award of 3d., which takes effect at once. The men have now 7s. 3d. per day, they work only five days per week, and the state of trade generally is such that they are not likely to receive any further increase. Coal shipments in the West of Scotland are reduced, but on the East Coast, and especially at Fife ports, they continue to show a considerable increase. Coal prices are generally unchanged.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Weather and the Coal Trade.

THE stormy weather, which continues without any abatement, is telling very seriously on the coal trade, as the diminished lists of clearances and sailings from the chief ports testify, and, should this continue so, it was stated on 'Change, Cardiff, this week, the result will be a glut of coal on the market, possibly some collieries stopped, and a weakening in price. On 'Change there are always men who take a desponding view, and these say that, as there is certain to be a brisk demand for coal again directly after the holidays, they predict that when this lessens, then a lessened requirement for coal by the various industries will precede the turn of the tide. I give this as the opinion of men usually well informed, but who disclaim being prophets. In the meantime, the weather is seriously hampering business, but the only instance of a wreck of a coal vessel this week on the Glamorgan coast was accompanied by quite a contest to secure the coals at auction, showing that the demand for coal is still strong.

Latest Coal Prices, Cardiff.

Some of the middlemen are quoting 18s. 9d. for best steam, but the closing prices officially are as follows:—Best steam, 19s. to 19s. 3d.; best seconds, 18s. to 18s. 6d.; ordinary seconds, 17s. 3d. to 17s. 9d.; best drys, 19s. to 19s. 6d.; ordinary drys, 17s. 9d. to 18s. 6d.; best washed nuts, 15s. 3d. to 15s. 6d.; seconds, 14s. to 14s. 6d.; best washed peas, 13s. to 13s. 3d.; very best smalls, 10s. 6d. to 11s. 3d.; best ordinaries, 10s. to 10s. 3d.; seconds, 9s. 6d. to 9s. 9d.; inferior, 8s. 6d. to 9s.; best Monmouthshire black vein, 17s. 6d. to 18s. 3d.; ordinary Western Valleys, 17s. 6d. to 17s. 9d.; best Eastern Valleys, 16s. 3d. to 16s. 9d.; seconds and other kinds, 15s. to 15s. 3d. Bituminous coal: Best households, 19s. 6d. to 20s. 6d.; best ordinaries, 17s. 6d. to 18s.; No. 3 Rhondda, 19s. 9d. to 20s.; brush, 16s. 6d. to 17s.; smalls, 13s. to 13s. 6d.; No. 2 Rhondda, 15s. to 15s. 6d.; through, 11s. 6d. to 12s.; smalls, 9s. to 9s. 6d.; patent fuel, 18s. 3d. to 18s. 9d.; coke, 19s. 6d. to 20s. 6d. for furnace, 22s. 6d. to 27s. for foundry, according to quality. Pitwood maintains its price, as stocks cannot be largely increased on account of the weather. Latest quotations: 24s. to 24s. 6d., Cardiff and Newport.

Anthracite.

Swansea prices continue steady. Stocks short. Inquiry good. Little change in prices, but firmer. Best malting, 29s. to 30s.; seconds, 27s. to 29s.; big vein, 26s. to 28s.; red vein, 20s. to 21s.; machine-made cobbles, 27s. to 28s. 6d.; nuts, 27s. 6d. to 29s.; peas, 14s. 6d. to 16s.; rubbly culm, 8s. 3d. to 8s. 9d.; duff, 5s. to 5s. 3d. Other Swansea quotations show firmness. Best steam, 19s. to 20s.; bunkers, 12s. 6d. to 13s. 6d.; small, 8s. 6d. to 9s. House coal: No. 3 Rhondda, 20s. 6d. to 21s. 6d.; small, 9s. to 11s. Patent fuel, 17s. to 17s. 6d.

Iron and Steel.

In pig iron there has been a tolerably good make, and only a few cargoes received at ports. Nearly a thousand tons came to Swansea last week, but only a cargo or so to Newport from Workington. Make of heavy rails has been good, and of steel sleepers a good average. One fine cargo of steel rails left Cardiff this week, 2000 tons, for India. Mills and furnaces moderately active; Cyfarthfa busy, and the progress of development at Dowlais unchecked. One of the items under discussion in iron circles is to the effect that American advices threaten to affect international arrangements, and promise rivalry in price, the condition of things in their iron and steel works being bad. The only quotations issued show pig prices little altered, some grades of pig iron a few pence better. Siemens bars, £5 5s.; Bessemer, £5 2s. 6d. Progress is shown at the Duffryn Steel and Tin-plate Works by extending tramway.

Tin-plate.

Some degree of excitement has been caused by the rumoured threat on the part of the United States Steel Trade Corporation, that if large regular purchases of American steel bars are not made in this country, say, to the extent of 3000 tons monthly, then they will be used up in their tin-plate markets, and a keen rivalry be carried out in all markets where Welsh and English plates are sold. A meeting has been held in Swansea to discuss the question. I do not hear of any alarm having been aroused in Wales. One of the authorities, commenting upon the rumour, says that the cost of tin-plate manufacture is much greater in America than in Wales, and the American Trust could only undersell at a ruinous loss. So until practical steps are taken, and the vanguard of great shipments arrive, no alarm need be felt, or even the matter discussed. Last week only 50,667 plates were despatched, but 84,980 boxes were received from works, leaving 184,052 tons in stock. At the Swansea meeting this week the American threat was regarded as bluff; still, there is no denying but that trade is getting quieter. At the Metal Exchange this week at Swansea it was stated that the market was unsettled and weak, and that this was chiefly due to forced sales by merchants at lower prices than the cost of make warranted. At latest date figures were retained, the ordinary Bessemer plates being offered at 13s. 3d. The official quotations are, however, at 13s.; ternes, 24s. 6d.; C.A. roofing sheets, £10; big sheets for galvanising, £10; finished black plates, £10 to £10 5s.; galvanised sheets, 24 g., £13 2s. 6d. Block tin is now £130 15s. Other quotations, Swansea, are:—Copper, £60 5s.; lead, £15 2s. 6d.; spelter, £21; silver, 25½d. per oz.; hematite pig iron, 67s. 7½d.; Middlesbrough, 49s. 4d.; Scotch, 59s.; Welsh hematite, 72s. 6d.

Iron Trade of the Year.

Compilers of statistics are now busily engaged in getting together the needed statistics for showing the business done by the various industries during the year. As a preliminary I just note with regard to iron and steel that the busiest month experienced by Cardiff was in November, when 7565 tons were exported, and the quietest in January, when only 2346 tons were shipped. Newport despatched 3252 tons in August, but on five occasions were under a total of 100 tons. Swansea, in April, 178 tons, and 2 only in November.

Coal to Foreign Destinations.

The amalgamation of Cardiff firms gives interest to the trade now carried out with foreign countries. During the year from Cardiff alone 150,703 tons were shipped to Genoa; 136,735 to Port Said; 95,119 to Buenos Ayres; 61,102 to Alexandria; 56,554 to Monte Video; 50,739 to Las Palmas; 51,295 to Rio Janeiro; 48,014 tons to Marseilles; and 42,391 to Havre.

Cardiff Waterworks.

The question of forming No. 3 reservoir in the Cwmtaff Valley for the supply of Cardiff from the Beacon sources is one of the subjects under consideration. Merthyr Tydfil also proposes, by largely increased supplies, to be in a position to supply Cardiff, and the Corporations would then be spared a heavy outlay, if satisfactory terms can be arranged.

Margam Waterworks.

It is alleged that an important crack has been discovered in the reservoir at Bryn. The matter is to be thoroughly investigated, and a sub-committee have already brought forward a report of a serious character.

The Great Northern Coal Contract.

In good quarters it is stated that the figures for this railway contract are from 17s. to 17s. 3d.

NOTES FROM GERMANY.

(From our own Correspondent.)

Quiet Trade in Rheinland-Westphalia.

LITTLE life is stirring in the iron and allied industries over here; even the large mixed works, which have been able to fill their order books by uncommonly low offers, begin to complain of a reduced activity, and of the poor amount of fresh work obtainable. Stoppages and rapidly decreasing quotations show the want of work, which is specially marked in the girder trade; the bar mills are in fair occupation on orders previously secured, but fresh orders come in very scantily. In the plate trade both demand and prices are most unsatisfactory. The prolongation of the Wire Rod Convention has had a somewhat stimulating effect on that branch of business; still, there is room for improvement. At a meeting on the 5th inst. the price for drawn wire has been reduced M. 7·50 p.t., present quotation thus being M. 132·50 p.t. In the wire nail trade an abatement in demand, both locally and on foreign account, is reported. Until now a fair business has been done in the pipe trade, and in the wagon and locomotive department a good activity at remunerative prices is going on. For 1908 large orders in railway material have already been given out, and there is more work pending; 710 locomotives, worth M. 49,000,000; 2105 passenger and luggage cars, worth M. 38,850,000, and 141,600 freight cars, worth M. 45,200,000, are to be delivered by October 1st, 1908. The machine shops complain of the reserve among consumers, and the hardware factories are but moderately employed. The Siegerland Iron Ore Convention is beginning to effect sales in iron ore for the first two quarters in 1908; the prices hitherto ruling will prevail for the first quarter, while for the second quarter the prices for roasted iron ore are about 0·75 lower than in the second quarter of present year, and for raw spathose ore 0·50 p.t. less is given than in this year, the basis quotation being accordingly M. 12·20 p.t. for raw iron ore, and M. 18·75 p.t. for roasted iron ore.

The Silesian Iron Market.

The iron and steel trade is very quiet indeed; orders are few, and there is much competition for the limited amount of work being offered. Prices tend in a downward direction. The ironfoundries for furnace grates and oven plates in Lower and Upper Silesia have formed a convention for prices, according to which the larger shops are to maintain the former quotations, while the small shops raise their prices M. 1 p.q.

Coal in Germany.

The coal trade is very brisk, and coalowners find themselves unable to satisfy the demands coming in. The Olsnitz collieries have raised the prices for house coal 0·50, and for engine coal 0·20 and 0·60 p.t. Coke is in very good call.

Decreasing Activity in Austria.

Trade is quiet now in nearly all branches of the Austro-Hungarian iron industry. Prices, too, are tending downwards in many instances. Pit coal and brown coal remains in strong request; still there was a decrease in the export of Bohemian brown coal from the 17th to 23rd of last month, 8186 t. less having been delivered than in the same week last year. Strikes are threatening in the Carinthian Collieries, the men asking for a 25 per cent. advance in wages.

Downward Tendency in France.

Both demand and prices have been weakening of late, and activity is decreasing. There was talk some time ago of large orders for locomotives which the French Railway Administration had granted to German shops. Now it is stated that the Orleans Railway has placed orders for ten locomotives with the Hanover Machine Company, and for twelve locomotives with the Alsace Machine Factory. Coal has not joined in the downward movement, and remains in excellent demand at firm quotations.

The Belgian Iron Business.

There is a marked downward movement perceptible in nearly all departments, and a good deal of depression has been felt. In many establishments activity had to be reduced, and there have been reductions in wages too in the Charleroi district. Business on foreign account is considerably hampered by the violent competition of German shops. Fresh work is so scarce that some shops in the Hainault district have announced their intention of dismissing part of their men. A strong inland trade at firm prices is being done on the coal and coke market of Belgium. Foreign sales, on the other hand, show a falling off.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MESSRS. KATZ BROS., Limited, of London, Singapore, and Penang, have been appointed sole agents for Messrs. A. Darracq and Co. (1905), Limited, for the Straits Settlements and Federated Malay States.

MESSRS. D. AND A. HOME MORTON, consulting engineers and industrial architects, of 130, Bath-street, Glasgow, inform us that, in order to give closer personal attention to their professional practice in the Midlands, they have established an office at 81, Francis-road, Edgbaston, Birmingham, with Mr. Andrew Home Morton as resident partner. This Midlands office will be worked in close association with the Glasgow office.

LIVERPOOL ENGINEERING SOCIETY.—The annual dinner of the Society will take place on the evening of Thursday, the 6th February, 1908.

INSTITUTE OF SANITARY ENGINEERS.—The annual dinner of the Institute of Sanitary Engineers was held on Wednesday, 11th inst., at the Holborn Restaurant. In the unavoidable absence of the late President, Mr. Baldwin Latham, and of the newly-elected president, Mr. Henry Adams, the chair was taken by Mr. Dibdin. There was a number of toasts, and a lengthy entertainment had been provided. Altogether a very enjoyable evening was spent.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS**, *M.I.Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.
When the abridgment is not illustrated the Specification is without drawings.
Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.
Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

24,567. November 2nd, 1906.—IMPROVEMENTS IN WATER-TUBE BOILERS, Edward T. Bousfield, of 44, Mapperley-road, Nottingham, and William R. Bousfield, K.C., of St. Swithin, Hendon.

This invention relates to water-tube boilers of the well-known type in which a main cylinder or shell is furnished with depending headers which are connected by small inclined tubes. There are four figures. Fig. 1 is a longitudinal section of the boiler. The main cylinder or shell *a* of the boiler has attached to it box-like extensions *b b* in lieu of the usual headers, which extensions are at right angles to the axis of the cylinder *a* and have arranged between them the small water tubes *c c* parallel with the axis of the main cylinder. The extension boxes *b b*, formed of two flat plates b^1 b^1 united to a frame b^2 of channel or trough section and

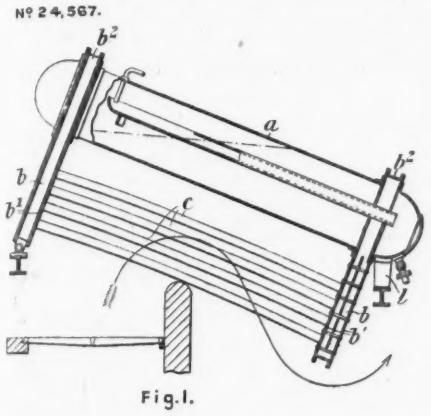


Fig.1.

bent to the desired external shape of the box, the upper part of the frame being of semicircular form and of a radius greater than the radius of the main cylinder, the flanges of the frame projecting outwardly. The plates b^1 b^1 are stayed on their flat surface and are provided with caps or plugs opposite to the several tubes *c*. The extension boxes *b b* may be attached to the shell *a* in alternative ways, according to two of which a hole is formed through the upper part of the extension box corresponding in diameter to the diameter of the main cylinder *a*, angle rings being provided, to which the main cylinder and extension boxes are riveted, the angle rings being, however, of less diameter than the circular portions of the frames b^2 of the extension boxes. By this construction of the shell and extensions, great strength is obtained, and the necessity for riveting through three thicknesses of metal is avoided and a large area of tube plate in proportion to the diameter of the barrel is obtained.—*November 17th*, 1907.

25,533. November 13th, 1906.—IMPROVEMENTS IN WATER-TUBE BOILERS, *Ernest Marriage, of* 39, *Gloucester-street, Toronto, Canada.*

This invention relates to improvements in water-tube boilers, and is designed to provide an arrangement of the parts forming a water-tube boiler in such a manner that the gases of combustion in their passage through the boiler are caused to pass continuously through the tubes joining the upper and lower drums of the boiler. There are six figures. A brick chamber 1 is lined with fire-bricks. At the front end is the fire-grate 2, and at the back end an opening 3 into the flue of the chimney. The boiler is formed of an upper drum 5 connected to a lower drum 6 by means of a series of straight tubes 7. The opposite surfaces 8 of the drums are flat-

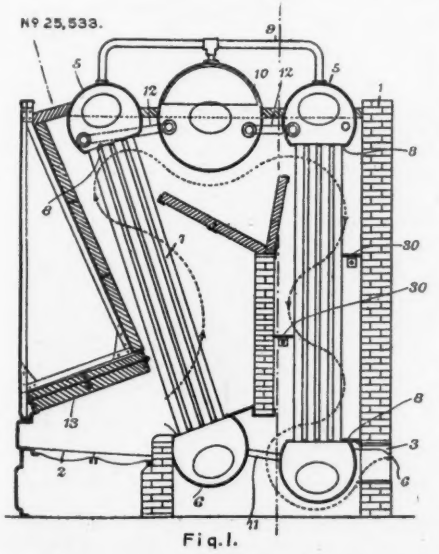


Fig.1.

tened, and the ends of the tubes 7 are expanded in the flattened surfaces. The upper drums 5 are connected by means of the steam pipe 9 and water pipes 12 with the large cylindrical steam and water drum 10. This drum 10 is provided with plates 29 adapted to deflect the steam downwards to separate the water from the steam. The steam is taken from the ends of the drums 5 where the water is in a comparatively quiet condition owing to there being no heat under it, and is deflected by baffle plates 29 on to water in a similar condition in the water and steam drum before passing out through the main steam outlet 30. The steam and water drum is about the same length as the upper drums, and rests with the upper drums upon the two side walls of the enclosing chamber. Owing to the length of the drums a portion of the water circulating through them is in a comparatively quiet condition. The lower drums 6 are shorter than the upper drums, and are enclosed within the walls of the brick chamber. The drums 6 are connected by means of water pipes 11.—*November 22nd*, 1907.

INTERNAL COMBUSTION ENGINES.

29,323. December 24th, 1906.—IMPROVEMENTS IN INTERNAL COMBUSTION ENGINES, Harry Parsons, of 150, Millbrook-road, Southampton.

This invention relates to certain improvements in that type of internal combustion engines in which the inlet and exhaust valves are combined one within the other, the outer valve being the inlet and the outer valve being the exhaust, both valves being mechanically operated. There are three figures. Fig. 1 is a sectional elevation; *a* is the fuel inlet valve and *b* the exhaust valve of the engine cylinder A. The body a^1 of the inlet valve *a* is provided with a piston packing ring a^2, and adapted to move in the cylindrical portion *c* between the inlet chamber *d* and the exhaust chamber *e*, so that the piston packing ring a^2 will prevent the hot exhaust gases firing back from the exhaust chamber *e* and igniting the incoming fresh combustible mixture in the inlet chamber *d*.

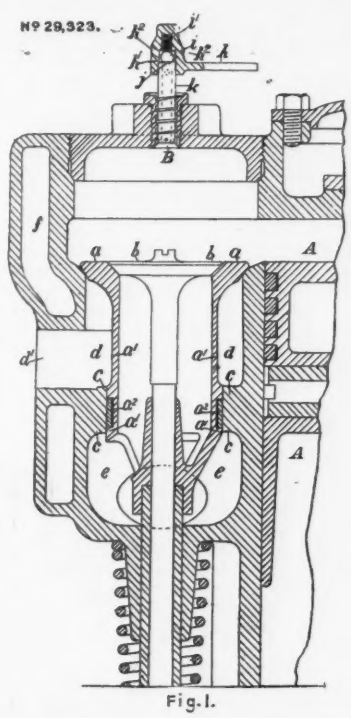


Fig.1.

The frictional resistance of the piston packing ring a^2 also prevents any tendency of the inlet valve *a* to lift with the exhaust valve *b* at such times as when starting the engine or when there is no pressure of combustion on the valves *a* and *b*. The inlet valve body a^1 is formed with a plain outer surface and so reduces the hot surface against which the incoming fuel spray through the passage d^1 from the carburetter strikes. The shortening of the valves *a* and *b* makes them lighter and quicker in action. B is the compression relief valve. The head of the valve spindle lever *k* is in the form of a hollow cap k^1 containing a ball valve *i* adapted to seat on and close the escape outlet *j* of the hollow valve spindle *k* on the suction stroke of the engine piston, a light compression spring i^1 being provided when necessary in the cap k^1 to hold the ball valve *i* to its seat. The hollow cap k^1 is provided with holes k^2 for the escape, when the compression relief valve B is open of the fuel during the compression stroke of the engine piston.—*November 22nd*, 1907.

4516. February 25th, 1907.—IMPROVEMENTS IN MECHANICAL MOVEMENTS, PARTICULARLY ADAPTED FOR OPERATING THE VALVES OF GAS ENGINES. *John A. Laird, of* 1324, *Chemical-building, St. Louis, Mo., U.S.A.*

This invention relates to a mechanical movement whereby a rectilinear reciprocation may be effected by a revolving shaft; and it relates particularly to means whereby a valve of a four-cycle gas engine may be actuated once for every two revolutions of the

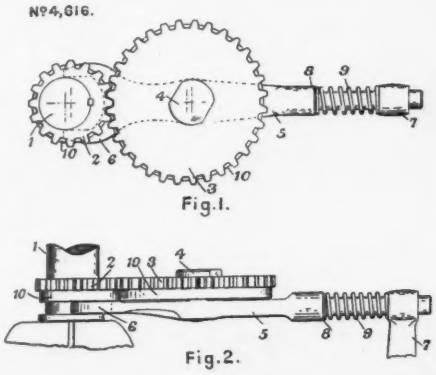


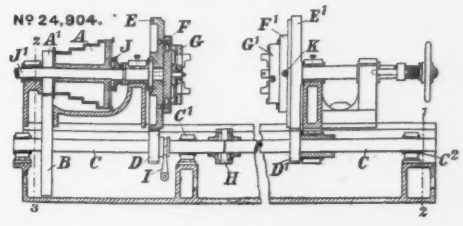
Fig.1.
Fig.2.

shaft. There are four figures. Fig. 1 is a vertical elevation. Fig. 2 is a vertical edge view. Mounted excentrically upon a driving shaft 1 is a gear wheel 2. Meshing with this gear wheel 2 is a second gear wheel 3, having twice the number of teeth. The gear wheel 3 is mounted excentrically upon a spindle 4 supported by a frame 5, bifurcated to form a yoke 6, which straddles the driving shaft 1. The yoke thus constitutes a guide for one end of the frame 5. The other end of the frame 5 extends through a hole or guideway provided in a supporting arm 7, in which hole it fits loosely, so as to permit the frame to slide therein. The frame is provided with a shoulder or abutment 8, against which bears one end of a coiled spring 9, which surrounds the frame and bears at its other end against the supporting arm. The spring 9 is arranged to push the frame normally towards the driving shaft, so as to keep the teeth of the gear wheels intermeshed. In order to secure the proper action of the gear wheels, they are both backed with discs 10 of smooth peripheries, which coincide with the pitch circles of the gear wheels. Their function is to relieve the teeth of the pressure of the spring, and with them it is practicable to use cast gears. The spring 9 pushes the frame towards the driving shaft, and keeps the large wheel 3 in engagement with the gear wheel 2 on the driving shaft. As the driving shaft revolves its motion is transmitted through the smaller gear wheel 2, so that the larger wheel revolves once for every two revolutions of the shaft. The gear wheels are originally set so that their points of maximum excentricity coincide, in which position the distance between the centre of the driving shaft 1 and the centre of the spindle 4 is the sum of the radii of the two gear wheels plus their excentricities. Consequently, when the smaller wheel has completed its revolution and the larger wheel has only half completed its revolution, the excentricities of the two wheels neutralise or offset each other, and the distance between the centre of the spindle is the sum of the radii of the two gears less the difference of their excentricities.—*November 22nd*, 1907.

MACHINE TOOLS.

24,904. November 6th, 1906.—IMPROVEMENTS IN OR CONNECTED WITH LATHES FOR TURNING CRANK SHAFTS, Joseph H. Potter, of Alexandra-street, Eastwood, Nottingham.

This invention relates to improvements in lathes specially constructed for turning crank shafts, which lathes have face-plates facing each other upon the one lathe bed, the face-plates being driven by pinions on a common shaft and carrying work-holders which are adjustable to the required excentricity and angle to enable the crank shafts to be turned. There are fifteen figures. Fig. 1 is a sectional elevation, showing the usual or fixed headstock in section and the loose headstock in elevation. Fig. 15



is a front elevation of the face-plate, with the excentric plate and chuck fitted in the central or zero position. The driving cone A is connected to and rotates with the pinion A^1, which gears with the spur wheel B. The spur wheel is keyed to and rotates the shaft C. Mounted upon the shaft C are two pinions D D^1, which engage with teeth cut on the peripheral faces of the face-plates E E^1. The pinions D D^1 have the same number of teeth, and the teeth on the edges of the face-plates E E^1 are the same in number. Therefore the face-plates E E^1 rotate at exactly the same speed. On each face-plate E E^1 is fitted an excentric plate F F^1 respectively, which excentric plate is adapted to be moved across the face-plate by means of a worm K, which gears with a rack let into each face-plate. The excentric plates F F^1 have each fitted thereto a four-jawed chuck G G^1. The driving shaft C is made in two lengths held together by a compensating coupling or joint H.

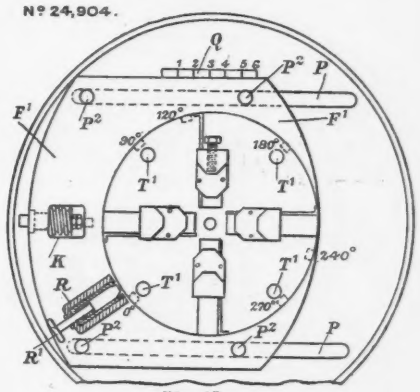


Fig.15.

The shaft C is, by means of a suitable crank lever I, adapted to slide the pinions D D^1 in or out of gear. When the shaft C has been moved sufficiently to the left to take the pinions D D^1 out of gear with the toothed face-plates E E^1, the fixed headstock and face-plate E can be used as an ordinary single-geared lathe. This is effected by means of a sliding-jaw clutch J, which clutches the fixed headstock spindle J^1 to the loose stepped or cone pulley A. By rotating the worm K in the excentric plate F^1 by means of the key head at the end of the worm spindle, the worm teeth gearing in the teeth of a rack within the plate, the excentric plate F^1 is moved by the worm and rack across the face of the face-plate E^1, in this manner giving the necessary degree of excentricity to the chuck G^1 carried by the excentric plate F^1. The ends of the crank it is desired to turn are secured in the jaws of the chucks G and G^1. By placing the excentric plates F F^1, which carry the jaw chucks G and G^1 respectively, at the required degree of excentricity, the crank-pin of a crank or a plurality of crank-pins in succession, if at different angles, can be brought to the centre with a minimum of labour and time.—*November 21st*, 1907.

ORDNANCE.

29,689. December 31st, 1906.—IMPROVEMENTS IN MOUNTAIN OR DISMEMBERABLE GUNS, Axel Bremberg, of Parkhead Forge Steel Works, Glasgow.

This invention relates to mountain guns, which of necessity are dismemberable into individual parts, the weight of each of which must not exceed a given amount. There are four figures. Fig. 1 is a longitudinal sectional elevation of the whole gun assembled. The barrel and chamber portion A of the gun are made in one piece, and a breech part B, carrying the breech block C, and its operating and firing mechanism D is secured in known manner upon its rear end. Interrupted parallel screw threads E of usual breech block form are cut upon the barrel part A and in the breech part B, and a worm mounted in the breech part B and engaging a segment of helical teeth upon the barrel part A is provided for relatively rotating the parts A and B, and locking them in position, the worm being operated by a handle applied to its spindle.

Upon engaging the parts together the worm enters a cavity at the end of the tooth sector, and is then in position to engage the helical teeth. In order that relative movement or "set" between breech part A and barrel part B may be compensated for, the breech block C is provided with a seating N (screwed therein and

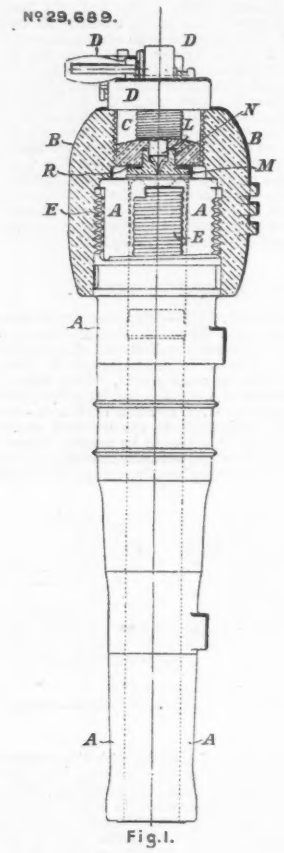


Fig. 1.

readily removable) for the forward end of the firing pin L, which seating has a flanged face M acting as a distance piece between the rear end of the cartridge case and the front of the breech block, washers or other packing R being placed between the flange M and the breech block C to compensate for distortion when that takes place.—*November 22nd*, 1907.

GAS PRODUCERS.

24,624. November 3rd, 1906.—A NEW OR IMPROVED COMBINATION OF GAS WASHING AND COOLING APPARATUS, George H. Bentley, of Oak Villa, Errwodd-road, Levenshulme, Manchester.

In removing tar, dust and other impurities from producer and like gas, and in cooling such gas prior to entering the usual scrubber, it has hitherto been customary to effect the operations in separate stages and in separate apparatus, the impurities being removed by varying the velocity and traverse of the gas in one apparatus, and the cooling being effected by bringing the gas in contact with cooling surfaces in another apparatus. There are

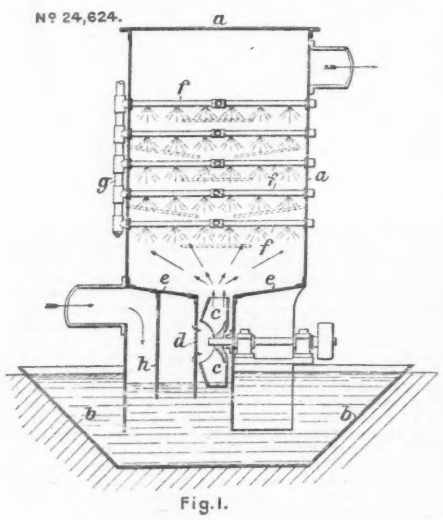


Fig. 1.

four figures. Fig. 1 illustrates an elevation in section of the combined gas washer and cooler. The apparatus consists of an open-bottomed, tower-like casing *a* mounted in a water-sealed tank *b*. In the lower part of such casing is a rotary fan washer *c*, and by means of suitable plates forming a casing the washer is enclosed on all sides, except at the bottom and top, and for a central opening *d* on one side. Such fan washer and the bottom edges of the plates, by which the washer is enclosed, dip slightly into the water seal. In the lower part of the casing *a* is a floor or partition *e*, which is preferably inclined downwardly towards the upper end of the fan casing. In the upper part of the main casing is a series of high-pressure water jets *f*, supplied with water from a pipe *g* common to all, and which deliver water downwards shower fashion, the water falling upon the floor of the casing and then flowing into the fan casing and down its walls, all of which are straight. In the lower part of the casing are also one or two slightly sealed partitions *h*. The gas from the producer first enters the lower part of the apparatus where, after passing under the plate *h*, it enters the central opening *d*. Meeting the fan (by which it is drawn into the casing) whilst rapidly rotating and whilst the water is thrown up by the fan, and also as the water flows down the inner walls of the casing, the gas becomes intimately mixed with the water, and, under the centrifugal action of the fan, the impurities are deposited into the lower part of the casing, where they sink to the bottom of the tank.—*November 17th*, 1907.

MISCELLANEOUS.

1397. January 19th, 1907.—IMPROVEMENTS IN AND CONNECTED WITH THE MARINER'S COMPASS, Commander Louis W. P. Chetwynd, of Coombe Neville, Kingston-on-Thames; Francis W. Clark, Director, of Kelvin and White, Limited, 18, Cambridge-street, Glasgow.

This invention relates to apparatus of the kind in which the controlling magnets of a mariner's compass are supported by their ends, which may be simultaneously raised or lowered by gearing. The magnets are carried horizontally on chains or bands running vertically over spindles carrying sprocket wheels mounted within the binnacle and driven by worm gearing, thus simplifying the methods of adjusting, so that any officer to correct an error caused by the change of ship's magnetism, &c., can do so without removing or adding to the number of magnets placed by the compass adjuster. The winding wheels are arranged so that the officer knows by consulting his compass instructions the turns necessary to raise or lower his magnets to eliminate the error. There are three figures. Fig. 1 is a vertical section of part of a binnacle taken below the compass bowl. The correctors or magnets *a* are fitted in the tube carriers a^1 placed horizontally on bands or chains *b* composed of brass or copper made to wind on

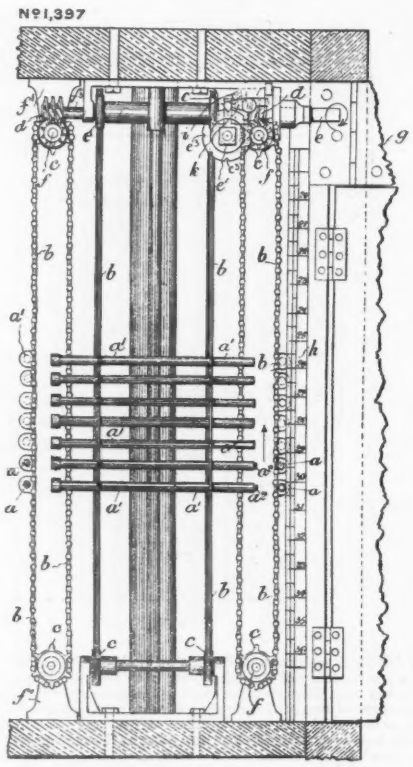


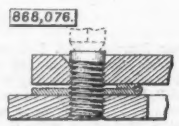
Fig. 1.

drum or mesh into sprocket wheels *c* actuated by worm wheels *d* driven by crank handles *e*, which gives a continuous movement to the correctors or magnet carriers a^1 of the smallest fraction of an inch, or the whole length of the scale as desired. This sliding movement cannot slip by the vibration of the ship, nor by the sudden shock from the firing of guns, but only by the intentional turning of the worm wheels *d* by the handle *e* provided for the purpose, thus doing entirely away with the necessity of clamping screws and the danger of them shaking loose, which is so common in the case of binding screws or racks and pinions as hitherto used. There are two sets of fore and aft magnets *a a* suspended by copper or brass chains *b*, the chains *b* of the fore and aft magnets *a a* and tube carriers a^1 a^1 being turned by the handle *e* giving motion to an inner shaft f^3 upon which the aforesaid worm wheels *d* are carried. Each spindle *f* mounted in brackets f^1 carries sprocket wheels *c* on which two sets of fore and aft magnets *a a* are suspended, has worm wheels *d* actuated by one small hand wheel *e* as previously referred to, so that in turning it the two sets of fore and aft magnets *a a* are raised or lowered by one operation. The thwartship magnets a^2 a^2 are lowered or raised by an independent hand wheel e^1, which by means of a worm wheel gives motion to an outer shaft or sleeve on which the chain or sprocket wheels *c* carrying the thwartship magnets a^2 are placed. The chain frames or bands *b* pass over the sprocket wheels *c*. The sprocket wheels *c* are fixed on each end of a spindle *f* running in bracket bearings f^1, the chains being, say, 5in. apart for an 8in. magnet. These chains or bands *b* carry brass tubes a^1 in which the magnets *a* are placed.—*November 22nd*, 1907.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

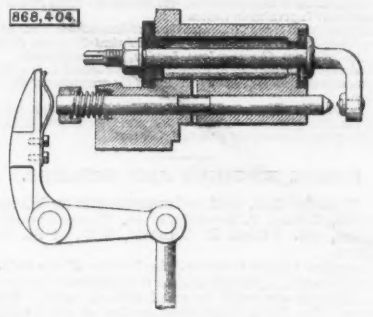
868,076. MEANS FOR JOINING PLATES. *W. Cross, Winnipeg, Manitoba, Canada.—Filed October 8th*, 1906.



This invention mainly applies to putting patches on boilers. A strip of soft metal, such as copper, is folded as shown, a wire put into the loop. There are two claims.

868,404. SPARK PLUG FOR EXPLOSIVE ENGINES, *F. W. Brady, Englewood, N.J.—Filed May 11th*, 1906.

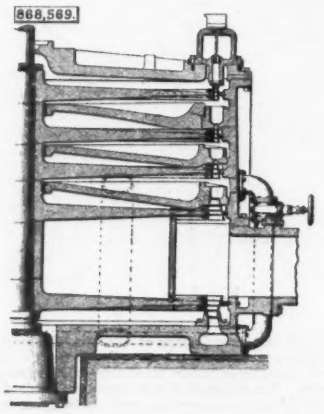
This invention is for a spark plug provided with a stationary electrode and a movable electrode, the stem of the stationary



electrode being supported in insulating bearings and surrounded with an air-insulation space communicating with draining passages, and the stem of the movable electrode being of reduced diameter for a portion of its length, interposed in the path of the draining passages. There are two claims.

868,569. ELASTIC-FLUID TURBINE, *O. Junggren, Schenectady, N.J., assignor to General Electric Company, a Corporation of New York.—Filed May 26th*, 1904.

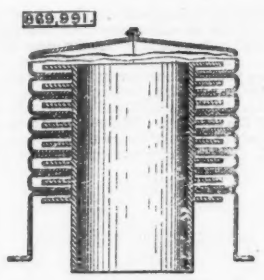
There are twenty-one claims to this patent. The last runs as follows:—In a multi-stage turbine, the combination of a casing, diaphragms dividing the casing into compartments, internal



shoulders to support the diaphragms, high-pressure wheels, nozzles which discharge motive fluid to a portion of each of said wheels, the latter being arranged to receive motive fluid in series, low-pressure wheels arranged to receive motive fluid from the high-pressure wheels, all of the buckets of which are active, and stationary nozzles arranged to direct the motive fluid against the buckets of the low-pressure wheels.

869,991. GAS ENGINE, *E. J. Stoddard, Detroit, Mich.—Filed April 29th*, 1907.

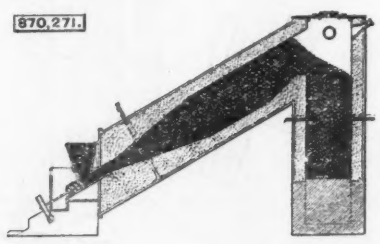
The invention claimed is a gas-engine cylinder having cooling ribs, and fins separate from said cylinder extending between the



cooling ribs so as to intercept the radiant heat from adjacent cooling ribs and prevent one of the cooling ribs from radiating heat to the other cooling ribs. There are seven claims.

870,271. GAS PRODUCER, *G. W. Bulley, New York, N.Y.—Filed December 19th*, 1906.

According to this invention, coal is fed into the lower end of an inclined retort, and moved up by an endless screw. Half-way up



the coal is ignited and delivered over the top of the incline into the vertical retort, as shown. Blast tuyeres are provided to secure combustion. There are thirteen very long claims.

THE proposal to increase the Australian duty on roofing slates exported to that country from 15 per cent. to 25 per cent. is exciting much anxiety among the quarry owners of North Wales, who export enormous quantities of slate to Australia. They have decided to petition the President of the Board of Trade to endeavour to secure a reduction in the tariff.

THE ROYAL COMMISSION ON COAST EROSION.

No. I.

WE referred in our issue of November 1st to the recently published volume of evidence given before the Royal Commission on Coast Erosion. In this and subsequent issues we propose to summarise some of the most important of this evidence from an engineering point of view. The labours of the Commission are not yet ended, and it is not expected that a report will be submitted until the latter part of next year. The volume just issued contains the first section of the evidence and appendices, covering twenty-three sittings from July 24th, 1906, to April 18th, 1907. The Commission was appointed in May, 1906, under the chairmanship of the Hon. Ivor C. Guest, M.P.; the other members are Sir W. H. Browne Ffolkes, Bart., Sir Leonard Lyell, Bart., Sir W. Matthews, K.C.M.G., Mr. W. P. Beale, K.C., M.P., Commander G. C. Frederick, R.N., Mr. A. Rider Haggard, Dr. T. J. Jehu, Mr. A. L. Lever, M.P., Mr. R. B. Nicholson, Mr. P. O'Brien, M.P., Mr. T. Summerbell, M.P., and Mr. A. S. Wilson, M.P., with Mr. C. H. Grimshaw, of the Board of Trade, as secretary.

The terms of reference to the Commission are as follows:—"To inquire and report (*a*) as to the encroachment of the sea on various parts of the coast of the United Kingdom and the damage which has been, or is likely to be, caused thereby; and what measures are desirable for the prevention of such damage; (*b*) whether any further powers should be conferred upon local authorities and owners of property with a view to the adoption of effective and systematic schemes for the protection of the coast and the banks of tidal rivers; (*c*) whether any alteration of the law is desirable as regards the management and control of the foreshore; (*d*) whether further facilities should be given for the reclamation of tidal lands."

The evidence given so far may be divided roughly into four categories, the first of which includes the evidence of officials representing public departments. The second category includes the geological witnesses, the third the expert engineering evidence, and the fourth the evidence of representatives of local authorities, including some surveyors to such bodies. It is the evidence given under the first-named category that we propose to consider in the present article.

The first witness called was the Hon. T. H. W. Pelham, C.B., Assistant Secretary of the Board of Trade, in charge of the Harbour Department, which controls, *inter alia*, Crown foreshore and the interests of navigation on the coast line of the United Kingdom. The witness defined the term foreshore as the land lying between high-water mark and low-water mark, although the Crown Lands Act of 1866 includes under this term the bed of the sea within the three mile limit as well. In England and Ireland the landward boundary of the foreshore is taken as being the line of high water of an ordinary or mean tide, that is to say, a tide just half-way between spring and neap. In Scotland the landward boundary is taken as being the line of high water of ordinary spring tides. Throughout the evidence given before the Commission the term foreshore was used in the more ordinary sense, that is, excluding the bed of the sea. Colonel Hellard, the Director-General of the Ordnance Survey, supplemented Mr. Pelham's evidence at a later date by a reference to the judgment of the Lord Chancellor of July 15th, 1854, in Attorney-General *v.* Chambers and Attorney-General *v.* Rees, which defined the higher limit of foreshore as the line of ordinary high water. "This judgment," says Colonel Hellard, "appears not to have been acted on by the Ordnance Survey uniformly in England and Wales till the year 1868, and it was held not to apply to either Scotland or Ireland. In Scotland no departure from previous practice was made, and the tide lines of ordinary spring tides have been adopted throughout by the Ordnance Survey. In Ireland, all the earlier surveys show the high and low-water lines of ordinary spring tides, but since the commencement of the 25in. scale survey in 1889 the high and low-water lines of ordinary tides have been adopted, and these are the lines shown on all plans of Ireland published since."

Up to 1866 the rights and interests of the Crown in the foreshore and bed of the sea were under the management of the Commissioners of Woods and Forests. By the Crown Lands Act of 1866 these rights were transferred and placed under the management of the Board of Trade, but there were numerous exceptions to this transfer. In consideration of the transfer, a sum of about half a million sterling was paid to the Land Revenues of the Crown. The exceptions included the foreshores of the Thames and the Tees, the County Palatine of Durham, foreshore fronting Crown property, and foreshores which have been dealt with by any instrument by the Commissioners of Woods before 1867. The Commissioners also retained the mineral rights. The foreshore of Lancashire belongs to the Duchy of Lancaster, and that of Cornwall and part of Devon to the Duchy of Cornwall, except where portions have been sold to private owners. The Board of Trade manage the foreshore in the interests of the public, and do not sell or lease any part of it except for some useful work in immediate contemplation, or for the purpose of control by some local authority.

The Board of Trade also exercise the powers of control transferred by the Admiralty, under the Harbours Transfer Act, 1862, over all foreshore and bed of the sea, irrespective of ownership, in so far as the interests of navigation are concerned.

The sales and leases of foreshore by the Board have during the past ten years brought in an average of £1215 per annum, but the rentals and considerations exacted are for the most part nominal, and very much less in proportion than are charged by the Commissioners of Woods, who exact the full market value in all cases.

Under the Harbours Act, 1814, and the Transfer Act of 1862, the Board have power to issue Orders, prohibiting the taking or removal of shingle or ballast from the shores or banks of any port, harbour, or haven of the United Kingdom. It has been held that every part of the coast is included within some Customs port, and that the Orders apply to shores and banks above as well as below high-water mark. The practice of the Board is to issue such Orders after application has been made on behalf of some local authority or other interest, and if it appears to the Board, after a local inquiry has been held, that continued removal is likely to cause damage to the coast or to navigation. The powers of the Board in this respect extend to foreshore in private ownership. The only dispensation from the operation of an Order which it is in the power of the Board to grant is in respect of the taking of ballast for ships. Mr. Pelham considers that the Board should also have discretionary powers to grant licences for the use of beach material within the limits of a prohibitory Order for the purpose of constructing sea defences on the foreshore included in the Order, when, in the opinion of the Board, other interests are not prejudiced thereby. The Board have no funds at disposal to carry out sea defence works. The only works of that description constructed by the Board of Trade are the groynes at Spurn Point, which were first erected by the Admiralty in 1851. In 1863 the maintenance of them was transferred to the Board, and new groynes erected. The question of extending these defences northward is now under consideration. The groynes were erected for the purpose of protecting the coastguard station and preventing a threatened breach through the neck at the back of Spurn Point into the estuary of the Humber. The total expenditure from public funds in connection with the works carried out at Spurn since 1851 appears to have been £59,433, in addition to £14,227 from the Mercantile Marine Fund for the protection of the foreshore in front of Spurn Lighthouse.

Mr. Pelham was also examined with reference to the much talked of Hall Sands case. It will be recollected that in 1896 the firm of Sir John Jackson, Ltd., applied to the Board of Trade and the Commissioners of Woods and Forests for permission to remove shingle from Start Bay, in the vicinity of Hall Sands and Bee Sands, for use in making concrete for the Keyham Dockyard works. In consequence of threatened damage to the village and foreshore of Hall Sands, the licences which had been granted were revoked in January, 1902, and fourteen months later a heavy gale resulted in considerable damage to the houses and sea walls in the village. Eventually compensation was paid to the sufferers by the contractors, and the royalties received by the two departments were returned to Sir John Jackson.

A list of the Prohibitory Orders of the Board of Trade now in operation was put in by Mr. Pelham. All of these, with the exception of two applying to the coast between Hornsea and Spurn Point in Yorkshire—1868-9—have been issued since 1896. In all fifty-two Orders exist, applying to about 131 miles of foreshore, a very small proportion of the entire coast line of the United Kingdom.

The witness regarded the Act of 1814 as cumbersome and wanting in elasticity. Groynes have been erected by Commissioners of Levels, such as the Romney Marsh Commissioners, without the consent of the Board, even on navigation grounds. Mr. Pelham stated that this consent should be obtained, but is not, the Commissioners claiming the right to erect without consent. The Board have no power to order the removal or destruction of a groyne, or any part of it, even when injury may be caused to other property. In the case of groynes erected on the Board's foreshore, the witness believed they had the right to order removal if required, but it would be very difficult to enforce such an order. Summarising his evidence, the witness intimated that legislation is necessary to confirm, extend, and modernise the powers of the Board of Trade with reference to foreshores, and that the public interest would be served by the creation of one authority to deal with the question without taking away any proprietary right from other parties. He saw no grave practical difficulty in the creation of such an authority; and if the Board of Trade were to be the central authority they would like to depend more and more on the assistance of local authorities. He approved of the substitution of local authorities, under the control of the central board for the old Commissioners of Levels and Sewers. Mr. Pelham concluded his evidence by stating that in his private opinion it was possibly desirable that any money received by the department in respect of the sale of foreshore should be spent for the protection of the coast.

Mr. R. E. Cunliffe, the solicitor to the Board of Trade, amplified the evidence given by Mr. Pelham on the legal aspects of the question. He stated the legal powers and limitations of the Board in some detail, and put in lengthy statements embodying abstracts of the more modern statutory provisions relating to foreshore, a digest of foreshore cases, and copies of forms of lease, conveyance, and licence granted by the Board of Trade. All these are printed as appendices to the evidence, and form a most useful statement of the law relating to foreshore. As regards the law of accretion (either by alluvion or dereliction,* it is held that if the gain is by small and imperceptible degrees it shall go to the adjoining landowners, but if it be sudden or considerable, the land shall go to the King as Lord of the Sea. The judgment in the case of Attorney-General *v.* Reeve laid down that where accretions of land on the seashore are shown to have been perceptible by marks and measures as they took place, such accretions belong to the Crown and not to the adjacent private owner. "Thus," said the witness, "the principle by which alluvions or imperceptible accretions go to the owner of the lands adjoining is inapplicable when the original boundary line can be clearly made out by marks, maps, evidence of witnesses, or any other means." In the converse case of encroachments by the water on the land, if the encroachment be gradual or imperceptible, the land thereby covered with water belongs to the Crown, whose property will consequently extend as far as the new high-water mark. "But if the encroachment of the water is sudden and violent the change of property takes place only during the inundation, and upon the recession of the water the private owner will retain and take again his land, if there are well-defined marks by which these boundaries can be shown. The land recovered would, however, be charged with the repayment of the whole, or of a proportionate part of the cost, of any works which have had the effect of causing recession of the sea and recovery of the land."

As to the much debated question of the obligation of the Crown to protect the coast line, Mr. Cunliffe interpreted the duty as an obligation to prohibit, or not to do itself anything to cause danger, but that the obligation actively to take part in protecting the coast by works has not been recognised by the Crown except through the medium of its subjects, they finding the money.

Evidence was given by Mr. C. E. Howlett and Mr. F. Hellard on behalf of the Commissioners of Woods and Forests, which department administers the proprietary rights of the Crown in foreshore not transferred to the control of the Board of Trade in 1866, and not included in the counties of Durham, Lancaster, and Cornwall. The length of frontage of Woods and Forests coast foreshore in the United Kingdom is 328 miles, measured at high water, as compared with a total frontage of 7578 miles, or about one-twenty-third of the whole. In the estuaries of rivers the Woods and Forests control 528 miles of frontage, as against a total of 10.553 miles, or about one-twentieth of the whole. Mr. Howlett states that the Commissioners agreed with Mr. Pelham in thinking that it is in the interests of the public for one department to be responsible for the control of the foreshore without prejudice to existing proprietary rights. He considered that the terms of the Harbours Act of 1814, conferring the powers under which prohibitory Orders are issued, should be extended to include the removal from the foreshore and sea banks of rock and materials other than shingle and ballast.

Colonel R. C. Hellard, R.E., who appeared before the Commission on two occasions, offered the most interesting evidence that has as yet been put forward on behalf of Government departments. As Director-General of the Ordnance Survey he has prepared a series of maps of the coast line of the United Kingdom showing the relative erosion and accretion since the earliest authentic surveys of the department. The comparisons thus made possible are very valuable and instructive, but they are, unfortunately, rendered somewhat complicated by the fact that many of the older surveys carried out in England and Ireland before 1868 give the high and low-water lines of ordinary spring tides, and not of mean tides as now placed on the Ordnance sheets. We have referred to the reason for this difference in dealing with the evidence of Mr. Pelham. Fortunately, for the sake of comparison the counties in which the greatest changes have taken place in the past thirty to forty years are for the most part those for which the surveys are directly comparable. Northumberland, Durham, Yorkshire, and Cumberland in England were surveyed originally at spring tides. Kent, Hampshire, Dorsetshire, Pembrokeshire, and Lancashire were surveyed originally partly on the mean tide basis and partly on spring tides. The whole of the Scotch coast was surveyed to the spring tide lines at all dates. In Ireland all the earliest surveys are to spring tides and the later to mean tides. The surveys made at spring tide levels will naturally show a less area above high-water mark than those made at mean tide levels. On the contrary, the areas of foreshore appear less on the basis of mean tides than they would do when measured to the spring tide marks. Taking the figures put in by Col. Hellard as they stand, Table I. shows the totals for England and Wales, Scotland and Ireland.

TABLE I.

Average interval between dates of surveys.	Country.	Loss of land above H.W.	Gain of land above H.W.	Difference net gain.	Loss of foreshore to sea.	Gain of foreshore to sea.	Difference net loss.
		Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
About 28 years	England and Wales	4692	35,444	30,752	44,629	13,397	31,232
,, 42 years	Scotland	815	4,704	3,889	12,447	4,076	8,371
,, 57 years	Ireland	1132	7,853	6,721	13,031	5,560	7,471
		6639	48,001	41,362	70,107	23,033	47,074

The figures referring to the foreshore are calculated from the relative positions of the low-water line. When the low-water line has been driven seaward the difference in area is counted as a gain to foreshore and *vice versâ*. It is somewhat curious that, together with a large increase in the dry land areas, there has been a decided loss in foreshore area. This discrepancy can be accounted for in part by the difference in the survey lines at various dates

* Alluvion means the accumulation of alluvial deposit; dereliction is where from the recession of the water the land is left dry.

which we have referred to above, but this explanation is not altogether sufficient, for in Scotland, where all the surveys have been made to the spring tide levels, the same difference exists. The figures for foreshore gains in the statements for England, Wales, and Ireland, are smaller than they would be if the comparison were a true one, and the losses of foreshore are above the truth. The same reasoning applies to the land figures, but in a lesser degree, for the reason that the gradient of the foreshore, on nearly all coasts subject to erosion, is very much flatter at and near low water than near high-water mark. We have in mind many places on the coast where the lines of high-water of ordinary spring tides and high-water of mean tides would be only a few yards apart, but where the corresponding low-water contours would be separated by several hundred feet. This is especially true of the foreshores in flat and sandy tidal estuaries. The large foreshore loss in Scotland, where the comparison is a true one, is accounted for by two particular instances in Dumfriesshire and Kirkcudbrightshire. In these two counties the loss of foreshore is as much as 10,192 acres, or over 80 per cent. of the figures for the entire country, and is due largely to extensive foreshore erosions in Solway Firth, at Southerness Point, and on the Blackshaw Bank. With these exceptions the losses and gains of foreshore in Scotland about balance each other.

If we consider the figures given by Colonel Hellard for England and Wales, arranging the counties in accordance with the basis of survey, we have the result shown in Table II. The figures in Section A afford true comparisons. Those in Sections B and C, in whole or in part, give areas of gain to the land from foreshore, or loss to the sea from foreshore, in excess of the true figures.

Table II.

Date of original surveys.	Date of latest survey.	County.	Loss of land above H.W.	Gain of land above H.W.	Loss of foreshore to sea.	Gain of foreshore to sea.	
			Acres.	Acres.	Acres.	Acres.	
1883—88	1903—5	Lincolnshire	400	9,106	1,009	177	A. All surveys at mean tide levels
1883—86	1903—5	Norfolk	339	3,480	1,720	877	
1879—85	1902—4	Suffolk	518	151	641	143	
1872—75	1891—96	Essex	168	562	2,902	771	
1871—76	1896—98	Sussex	374	1,018	2,725	396	
1860—89	1892—1905	Devon	36	138	394	106	
1859—84	1905—6	Cornwall	7	48	29	19	
1883—88	1902	Somerset	33	256	924	491	
1875—79	1896—99	Glamorgan	64	1,406	2,877	308	
1878—85	1905	Carmarthen	131	606	3,600	1047	
1885—87	1904	Cardigan	11	138	117	114	
1886—87	1899—1900	Merioneth	14	300	69	294	
1887—88	1898—99	Carnarvon	5	44	323	456	
1886—87	1899	Anglesea	9	238	714	121	
1870—75	1898	Denbeigh	12	39	47	60	
1869—72	1897—98	Flint	70	413	2,982	737	
1870—74	1897—98	Cheshire	104	59	2,052	932	
			2295	18,002	23,125	7049	
		Difference	15,707 gain		16,076 loss		
1855—64	1894—97	Northumberland	18	1,630	960	93	B. Earlier surveys spring tides, later surveys mean tides
1855—57	1894—97	Durham	15	1,994	902	626	
1848—53	1888—93	Yorkshire	774	2,178	3,827	480	
1859—66	1897—99	Cumberland	277	1,096	3,406	1609	
			1084	6,898	9,095	2808	
		Difference	5,814 gain		6287 loss		
1858—76	1905—6	Kent	526	519	4,871	630	C. Earlier surveys par. spring tides and part mean tides, later surveys mean tides
1856—70	1895—97	Hampshire	198	852	738	281	
1862—88	1900—2	Dorset	35	52	225	109	
1864—88	1904—6	Pembroke	9	31	287	56	
1842—48	1888—93	Lancashire	545	9,090	6,288	2464	
			1313	10,544	12,409	3540	
		Difference	9231 gain		8869 loss		

If we take the counties of England, it appears that three only show a net loss of dry land. These are Suffolk with 367 acres, Cheshire with 45 acres, and Kent with 7 acres. In the first two cases the figures are true, and in the case of Kent the true loss is probably greater than the figure given, owing to the disparity of the tidal levels in the surveys. All other counties show a net gain of dry land. In the case of Durham the principal changes have been reclamation at Sunderland in connection with the harbour and docks and accretion in the Tees estuary. In Yorkshire the accretion exceeds the erosion north of Flamborough Head, but from Flamborough Head to Spurn the erosion has been the most serious in the United Kingdom. Reclamation has taken place principally at Sunk Island and Spurn Head. In Lincolnshire the large gain is accounted for by reclamation in the Wash and accretion at Saltfleet. Reclamation also accounts for most of the gain in Norfolk. In Suffolk there has been general erosion on the coast line, especially about Southwold and Lowestoft. In Essex the principal erosions are at the Naze and Foulness; accretion has taken place between the rivers Crouch and Blackwater. In Kent erosion has occurred from Sheerness to Herne Bay, and reclamation at New Romney and Dungeness. Sussex shows accretion at Pagham and Rye harbours, and erosion near Beachy Head and west of Selsey Bill. In Hampshire there has been reclamation in Brading Harbour and erosion between Christchurch and Poole. In Dorset, Devon, and Cornwall the changes have been insignificant. Somerset shows accretion in Bridgwater Bay, and in Glamorganshire there have been extensive reclamations at Barry and Cardiff; but the large erosion of foreshore is difficult to account for except on the score of dredging within harbours and approaches to harbours over areas which were formerly mud flats. In Carmarthenshire there has been accretion at the mouth of the Towy, but here, again, the large net loss of foreshore is hard to explain. No other changes of importance have occurred on the Welsh coast until Flint is reached, where accretion of land has taken place at the mouth of the Dee, attended by erosion of foreshore. Erosion in the estuary of the Dee has resulted in a loss to Cheshire; but the large foreshore loss recorded for the county may be due to changes in the extensive sandbanks dry at low water between the mouths of the Dee and Mersey. The figures for Lancashire are, unfortunately, vitiated by the difference in the survey lines adopted for the earlier and later surveys. Reclamation or accretion has taken place at Barrow-in-Furness, Morecambe Bay, and Southport; but undoubtedly a considerable portion of the apparent net gain of dry land, viz., 8545 acres, must be due to the lower level taken for high-water mark in the later survey. The very large apparent net loss of 3824 acres of foreshore is probably more than accounted for by the same reason.

The greater part of the land gain recorded by Col. Hellard is due to artificial reclamation, but unfortunately the witness was unable to give any definite information as to the relative proportions of natural accretion and artificial reclamation. He stated, however, that if the figures referring to Lincolnshire, Norfolk, and Lancashire are eliminated, the remaining data in the tables apply to parts of the coast where very little artificial reclamation has taken place. The three counties we have named show a total gain of dry land of about 20,000 acres, leaving a little over 10,000 acres of gain to be divided among the remaining counties of England and Wales.

The evidence of Capt. W. F. Maxwell, R.N., of the Hydrographer's Department of the Admiralty, generally confirms the statements of Col. Hellard as to the loss of foreshore to the sea. Capt. Maxwell stated that, as a rule, the gradients of the foreshore towards low-water mark had become steeper, thus reducing the area of foreshore even in some cases where the high-water line had remained stationary or extended seawards. The witness described the changes taking place in sand and shingle banks off shore, especially on the east coast of England.

Mr. N. T. Kershaw, one of the assistant secretaries of the Local Government Board, gave evidence as to the powers of his department in sanctioning loans for sea-defence works. The Board grant periods for repayment of loans as follows:—Timber groynes, ten years; concrete groynes, twenty years; and sea walls, twenty years. He considered that it would be very undesirable if the powers now possessed by the Board of controlling and authorising loans to local authorities in relation to sea-defence works should be transferred to any other department.

STRENGTH OF RINGS.

A letter by "A. H. C." published in our issue of November 1st, 1907, stating that he could find no formula for calculating the breaking strength of rings, and asking for information, has raised an interesting discussion in the correspondence columns of The Engineer. It is to be observed that "A. H. C." asks for the breaking strength, and it is to be presumed that, having got it, he would apply a factor of safety of, say, 3 for a steady load, and, say, 5 for a variable load, and feel quite happy about the result. If, however, by breaking strength is meant the load that would rupture the material of the ring, the apparent safe load thus obtained would be, as will be shown later, in the case of a mild steel ring 4in. internal diameter and of 1in. diameter bar, no less than 18 times the load that would permanently deform the ring, and 5·5 times the safe load. In fact, this ring problem is an excellent example of the fallacy underlying the process of applying a factor of safety to the breaking load or ultimate strength. In most cases the fallacy is hidden because the safe stress and the ultimate stress in the structure are approximately proportional, so that it is only arithmetically that the calculation is different.

In the case of a ring, as in all cases, the safe stress must not be exceeded at any point when the ring is still a ring of the original shape—that is, has not been exposed to more than elastic deformation. The ultimate stress only occurs, however, with a ductile material, when the ring has been pulled out into the shape shown in Fig. 1. Failure will take place by almost pure tension, and it will be seen that the ultimate strength is independent of the diameter of the ring, and is somewhat less than twice the resistance to tension of one bar of the same section as that of the ring. The fallacy of basing a calculation for safe strength on the ultimate strength is thus made evident.

Mr. G. J. Wells gives an investigation at page 476—November 8th, 1907—from which the safe load can be calculated. He shows that at A, the top of the ring, the bending moment is $\frac{W R}{\pi}$., and he then tacitly assumes that the maximum tensile stress will occur at B on the horizontal diameter—E. C. Moyle, page 552, definitely states that the greatest bending moment occurs at this point—as a matter of fact, however, not only is the bending moment greater at the top (or bottom) of the ring than at the horizontal diameter, but the intensity of tensile stress is also greatest there, as can be shown as follows*:—

As shown by Mr. Wells, the maximum tensile stress at B (on the horizontal diameter) due to the bending moment is

$$\frac{4 W R}{\pi r^3}\left(\frac{1}{2}-\frac{1}{\pi}\right)$$

and the uniform tensile stress is

$$\frac{W}{2\pi r^2}$$

Hence the maximum tensile stress is

$$\frac{W}{\pi r^2}\left[\frac{4R}{r}\left(\frac{1}{2}-\frac{1}{\pi}\right)+\frac{1}{2}\right]$$
$$=\frac{W}{\pi r^2}(0{\cdot}726\,R+0{\cdot}5\,r).$$

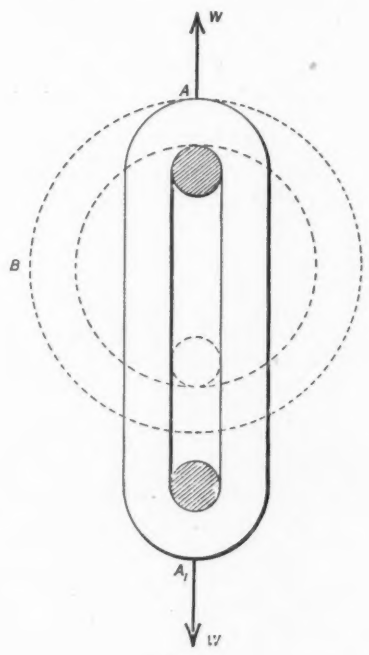


Fig. 1

But at the top of the ring, at A, the maximum tensile stress is

$$\frac{W R}{\pi}\cdot\frac{r}{I}\cdot=\frac{W}{\pi r^3}\cdot\frac{4}{\pi}\cdot R,$$

and is therefore greater than at B so long as

$$\frac{4}{\pi}R > 0{\cdot}726\,R+0{\cdot}5\,r$$

That is so long as

$$0{\cdot}548\,R > 0{\cdot}5\,r,$$

which can practically never be the case.

It will be seen, therefore, that the safe load for a ring can be calculated by substituting for f in the following formula the safe intensity of stress either in tension or compression suitable for the material of the ring and for the conditions under which it is working.

$$\text{Safe load} = \frac{\pi^2 r^3}{4R}\cdot f.=2{\cdot}46\frac{r^3}{R}\cdot f.\quad.\quad(A)$$

where r is the radius of the bar, and R is the internal radius of the ring plus the radius of the bar.

For example, if the material is wrought iron and the load is steady, f may be taken at 5 tons per square inch; if the load is variable f would be reduced to, say, three tons per square inch. Taking the numerical example given by Mr. Collingham at page 477, $r = \frac{1}{4}$in. and $R = 2{\cdot}5$in.

Hence for a steady load,

$$\text{Safe load} = 2{\cdot}46\ \frac{(\frac{1}{4})^3}{2{\cdot}5}\ .\ 5 = 0{\cdot}61 \text{ tons.}$$

With the same data Mr. Wells' formula would give

$$\text{Safe load} = \frac{(\frac{1}{4})^3\times 5}{0{\cdot}235\times 2{\cdot}5+0{\cdot}159\times\frac{1}{4}}$$
$$=1{\cdot}04 \text{ tons.}$$

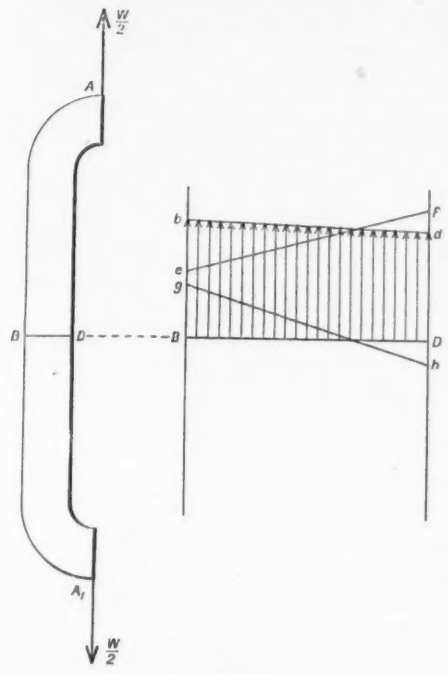
* Since this article was written, a letter by "W. B." has been received—published in issue of December 13th—in which this is pointed out.

a load which would produce a maximum intensity of stress at the top of the ring of

$$5 \times \frac{1{\cdot}04}{0{\cdot}61} = 8{\cdot}7 \text{ tons per sq. in.}$$

which is considerably in excess of what is permissible with wrought iron. Of course, with steel higher values of f would be taken.

If the load on the ring is increased until the intensity of stress at A, the top of the ring, reaches the yield point, the ring will be plastically deformed, and if the load is further increased it will be pulled out into the elongated form indicated in Fig. 1. The load at which this deformation begins can be found by substituting for f the yield stress;



Figs. 2 and 3

thus, if the yield stress is taken at 16 tons per square inch, the load at which plastic deformation begins in the previous numerical example is:

$$2{\cdot}46 \times \frac{(1/2)^3}{2{\cdot}5} \times 16 = 2 \text{ tons nearly.}$$

As already pointed out, when fully stretched, failure will take place by almost pure tension. To form some idea of this tensional resistance it will be seen that, if the ring were cut in half, as in Fig. 2, owing to the excentricity of the line of action of the load, the intensity of textile stress would be far from uniform over the cross section at B, as indicated by the line $e\,f$ in Fig. 3. But in the actual elongated ring the top fibres at A are in tension due to the bending moment, and this stress will be carried round to B, producing a further distribution of stress at B D, represented by $g\,h$ in Fig. 3. The exact distribution due to this bending moment will depend on the way the load is applied at A, but will tend to make the total distribution more uniform, as shown by $b\,d$, which is the summation of $e\,f$ and $g\,h$. Hence the

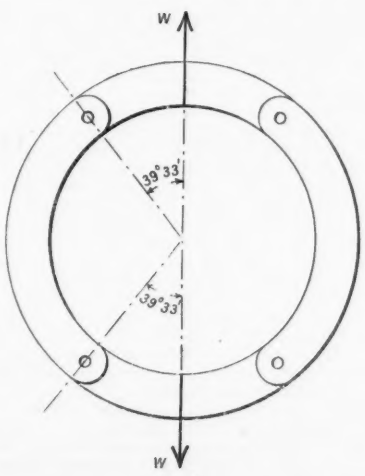


Fig. 4

ultimate resistance of each side of the distorted ring will be somewhat less, say, 10 per cent., than the ultimate resistance to tension of a bar of the same cross section. Thus, in the case of the numerical example already considered, and taking Mr. Collingham's figure for the ultimate resistance to tension, namely, 23·55 tons per square inch—see page 477—the ultimate strength of the distorted ring would be—assuming a reduction of 10 per cent.:—

$$2 \times 0{\cdot}9 \times 1^2 \times \frac{\pi}{4} \times 23{\cdot}55 = 33 \text{ tons.}$$

Taking a factor of safety of 3 for a steady load, the *apparent* safe load would be: $11/0{\cdot}61 = 18$ times greater than the safe load, and $11/2 = 5{\cdot}5$ times greater than the load that would permanently distort the ring.

The bending moment at A is of different sign to that at B; hence between A and B there must be a point where there is no bending moment. From Mr. Wells' letter we have

Bending moment at any point

$$= \frac{W}{2} \cdot R \cdot \sin\theta - M_1$$

$$= \frac{W}{2} R \sin\theta - \frac{W R}{\pi}.$$

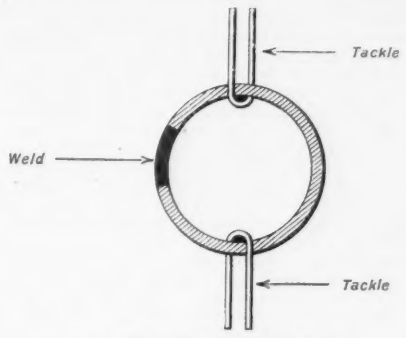


Fig. 5—ARRANGEMENT OF TEST

Equating to zero, we find

$$\text{Sin}\,\theta = \frac{2}{\pi}.$$

$$\text{or } \theta = 39° 11'$$

This can be experimentally verified by making a cardboard ring as shown in Fig. 4.

The above theoretical considerations have been verified by the following tests specially made for the purpose by Mr. P. H. Stanger at the testing works, 2, Broadway, Westminster. The table and the figures give all the particulars needed. The method of testing is shown in Fig. 5.

The wrought iron was purchased from a local firm of general engineers, which did the welding itself, the material being taken from stock.

a yield stress of $7{\cdot}8/0{\cdot}4657 = 16{\cdot}6$ tons per square inch.

The full results of the tests on the straight bars are as follows—

Dimensions.	Area, sq. in.	Reduction of area at fracture. Per cent.	Extension on 8in. Per cent.	Actual breaking load of specimen. Tons.	Calculated Tons per sq. in.
0·76in. dia.	0·4536	43·7 Specimen	25·25 unannealed	10·91	24·05
0·77in. dia.	0·4657	39·3 Specimen	27·0 annealed	10·50	22·55

Hence from formula A, the load at which permanent set will begin in the rings will be:—

For the 3in. ring—

$$W = 2{\cdot}46 \frac{(0{\cdot}38)^3}{1{\cdot}5 + 0{\cdot}38} \times 16{\cdot}6 = 1{\cdot}20 \text{ tons.}$$

For the 4in. ring—

$$W = 2{\cdot}46 \frac{(0{\cdot}38)^3}{2 \cdot + 0{\cdot}38} \times 16{\cdot}6 = 0{\cdot}94\text{in.}$$

For the 6in. ring—

$$W = 2{\cdot}46 \frac{(0{\cdot}38)^3}{3 + 0{\cdot}38} \times 16{\cdot}6 = 0{\cdot}66\text{in.}$$

From the stress-strain diagrams given in Figs. 7, 8, and 9, it will be seen that a distinct increase in the extension begins—

For the	3in. ring.	4in. ring.	6in. ring.
When the load is	3·0 tons.	2·0 tons.	0·7 tons.

It will be seen that except in the case of the 6in. ring the testing machine does not indicate any appreciable yield, although the yield stress has been reached at the top and bottom of the ring. The obvious reason is that at first it is only very short lengths of the ring at the top and the bottom which are stressed up to the yield point.

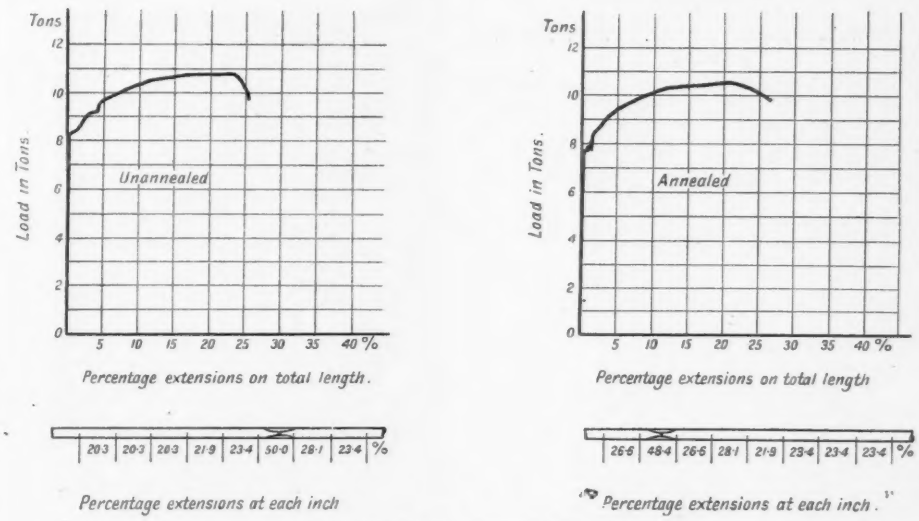
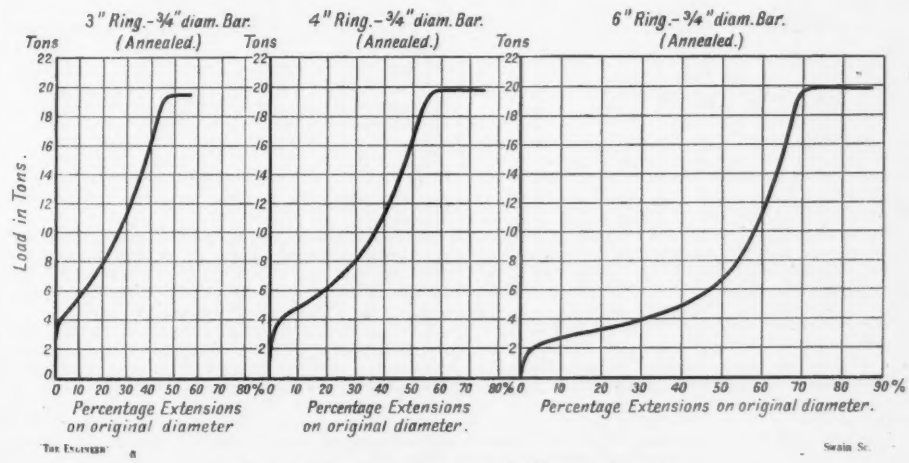

Tons
Load in Tons
Unannealed
Percentage extensions on total length.
20·3 20·3 20·3 21·9 23·4 50·0 28·1 23·4 %
Percentage extensions at each inch
Tons
Load in Tons.
Annealed
Percentage extensions on total length
26·6 48·4 26·6 28·1 21·9 23·4 23·4 23·4 %
Percentage extensions at each inch.

Fig. 6—TESTS OF STRAIGHT IRON BAR

As regards the ultimate strength, twice the tensile resistance of one $\frac{3}{4}$in. annealed rod is from the table $2 \times 10{\cdot}5$ tons $= 21$ tons, and from Figs. 7, 8, and 9 it will be seen that the ultimate strength of the

3in. ring is 19·5 tons, or 7 per cent. less than 21 tons.
4in. ring is 19·9 tons, or 5·2 per cent. less than 21 tons.
6in. ring is 20·0 tons, or 4·7 per cent. less than 21 tons.


3" Ring.-¾" diam. Bar. (Annealed.)
4" Ring.-¾" diam. Bar. (Annealed.)
6" Ring.-¾" diam. Bar. (Annealed.)
Tons
Load in Tons.
Percentage Extensions on original diameter
Percentage Extensions on original diameter.
Percentage Extensions on original diameter.

Figs. 7, 8, and 9—STRESS-STRAIN DIAGRAMS OF RINGS

The whole of the tests—straight and rings—herewith being from one bar $\frac{3}{4}$in. dia.

The three rings broke—6in. near tackle, 3in. and 4in. clear of weld. In all cases the weld was at the side of the ring.

From Fig. 6 it will be seen that the yield load—for the $\frac{3}{4}$in. rod—may be taken at 7·8 tons, corresponding to

Photographic reproductions of the broken rings are given in Fig. 10, and it will be observed that the 6in. ring failed at the top. It will be admitted that these tests substantially confirm the theory. Finally, it can be accepted that the safe load—that is a load less than the load which would cause permanent distortion—of a circular ring can be calculated from the formula—

$$W = 0{\cdot}615\,\frac{d^2}{D+d}\cdot f,$$

which is the A formula previously given, in which the radii have been replaced by the diameters; that is

D is the internal diameter of the ring in inches,
d is the diameter of the rod in inches,
f is the safe stress in tons per square inch, appropriate

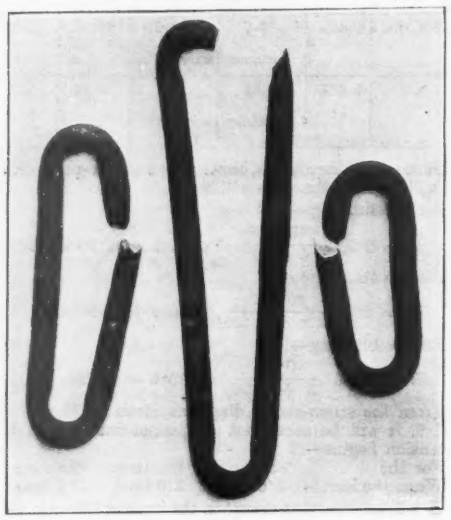


Fig. 10—RINGS BROKEN UNDER TEST

to the material, and to the condition of the loading, whether steady or variable.

GAS POWER PLANT AT AN ENGINEERING WORKS.

In 1898 what was at that time considered an excellent and up-to-date steam plant was laid down by Messrs. David Rowan and Co., of 231, Elliot street, Glasgow, for driving their works. So much was thought of this plant that a paper discussing it, and entitled "Power Required to Drive a Marine Engine Works,"* was read in 1901

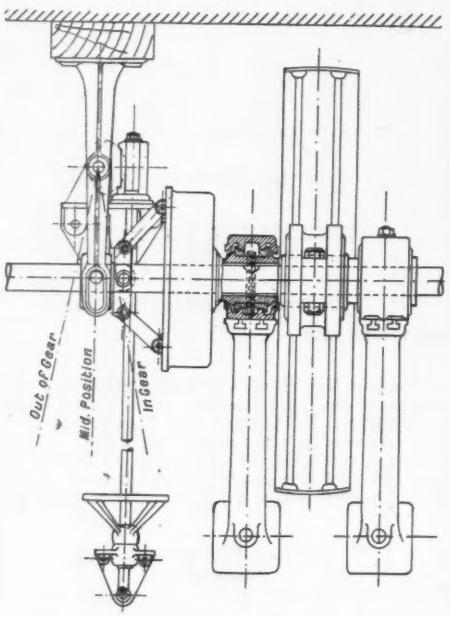


Fig. 1—SELF-CENTREING FRICTION CLUTCH

before the Engineering Congress held in that city. Notwithstanding this, however, Messrs. Rowan have recently done away with this comparatively new plant and have substituted for it gas engines using producer gas.

Previous to the installation of this steam plant the motive power had been obtained from a marine type boiler, working at 80 lb. pressure, and supplying steam to three vertical compound engines for power and to one vertical compound engine for lighting. The newer steam plant laid down in 1898 consisted of one vertical compound non-condensing engine, coupled to dynamos, the combined plant being capable of driving and lighting the whole works. During the night shifts the works were driven by electric motors taking current from the supply mains of the Glasgow Corporation.

In 1905, finding their floor space too cramped to meet efficiently the demands of their increasing business, Messrs. Rowan decided to extend their premises in certain directions to a considerable extent, and it became necessary to determine whether the steam plant should be duplicated or whether an entirely new form of power plant should be adopted, in order to get the cheapest possible power under their existing conditions. Acting on advice of Messrs. Hal Williams and Bridges, to whom the firm applied for advice, and to whom they entrusted the supervision of the work, Messrs. Rowan decided to do away with the steam engine altogether, and to substitute gas engines working in connection with suction gas plants burning Scotch anthracite coal.

We recently, by the courtesy of Messrs. Rowan, had an opportunity of making a long and careful inspection of this plant, and we propose to describe it in the following article. We have to record our thanks to Messrs. Rowan for the facilities for inspecting and taking notes of the installations they afforded us, and to Messrs. Hal Williams and Bridges for the particulars and drawings with which they have supplied us.

The first step to be taken before making the change was to ascertain exactly the total maximum prime power required by the old and new shops. After careful tests had been carried out this was found to be approximately 600 brake horse-power. As reliability was an essential consideration, and as it was necessary to deal with reduced loads during night shifts, and overtime in individual shops, &c., it was decided to subdivide this power into four units of 150 horse-power each. It was also arranged that the four gas engines should drive in parallel by belts on to one main shaft through friction clutches, and that three of them should each be belted to a direct current electric generator. The arrangement of the plant is shown on the plan, which we reproduce on page 617.

An examination of this plan will show that the available space was small, and naturally there was the great difficulty that the substitution of one form of power for the other had to be carried out without in any way interfering with the running of the shops. To meet this the gas engines marked A and B on the plan were first put in, and when these were fully at work the steam engine was removed, and the gas engines C and D were got into position. This was by no means an easy task, as the limited head room precluded the use of an overhead crane. In place of it the consulting engineers designed a series of overhead runways, which are shown

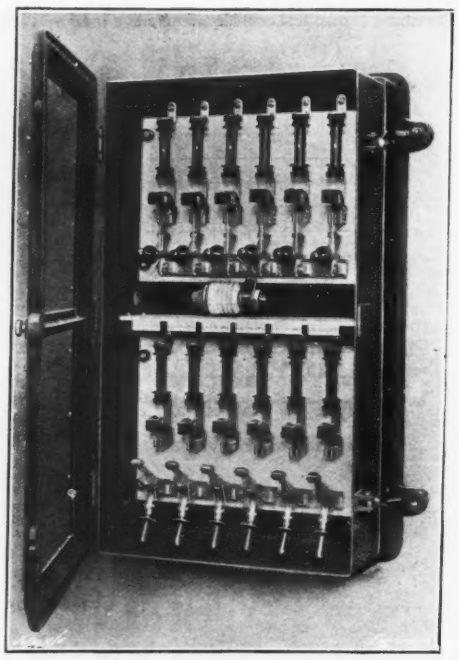


Fig. 2—SWITCH AND FUSE BOARD

by full black lines on the engravings. These runways are, of course, invaluable when it is necessary to open up the engines for cleaning the valves or other purposes. The contract for the gas engines and gas producer plants was secured by the National Gas Engine Company, of Ashton-under-Lyne, the producers being made by the Dowson Economic Gas and Power Company. The engines have a stroke of 30in. and a cylinder diameter of 22½in. They are constructed to develop their full horse-power at 170 revolutions per minute. In order to obtain as slight a cyclical variation as possible the fly-wheels were made especially heavy. They each weigh 12 tons 10 cwt. They are fitted with cast iron rigger rims bolted to the peripheries for taking the belt drives to the main countershaft, the faces of both riggers and fly-wheels being specially turned to suit the exacting conditions of the belt drives.

It is ordinarily the custom to run three of these engines at one time during the day time, the fourth being put to work for lighting in the evening. At the time of our visit the three engines were running very well together, working the dynamos and driving in parallel on to the main shaft situated overhead. They were running silently and well, the governors regulating the speed excellently in spite of a greatly varying load. About the running of the dynamos we shall have something more to say a little further on.

The four producer gas plants are arranged in line one behind each gas engine, as will be seen in the engraving on page 617. An equaliser pipe has been connected to each producer. This has been done for three purposes. First, it enables either engine to be run from either producer, so that any producer may, if required, be laid off for clinkering, &c., during working hours. Secondly, by opening all the valves connecting this pipe to each of the gas mains between the producer and the engines, the suction effect is equalised between all the producers, and in the event of the failure of either of the latter it could be isolated without affecting either of the engines. Lastly, when running one or two gas engines for night shifts or overtime, all the gas plants can be put on this load. This considerably reduces the standby losses and facilitates starting up in the morning, it only being necessary to start the other engines in the ordinary way without having to blow up the producers with the electric blower fans. We may say that each producer has its own fan, for the initial raising of gas. These are direct-coupled, electrically driven Sirocco fans. There is also a stand-by of a hand blower fan. When working at full load the whole of the producers, gas engines, and electric generators are inter-connected and in parallel, so that in the event of a failure of either one of the units, those remaining would take up the load and divide it between them. We are informed that each unit has been designed to deal with such an overload as this would entail for long periods. As will be seen from the engraing, Figs. 3 and 5, page 619, the stoking platform for the producers is carried along above the tops of the generators, coal being supplied to this platform by means of two coal bunkers which are provided with conical delivery ends. The stoking is, of course, done by hand. The coal is brought into the works in two-wheeled carts, which are hoisted up by an overhead travelling crane and placed on a dumping platform, whence the coal can be tipped into the bunkers.

Fig. 6, page 619, shows a view of the engine-room. The four gas engines are arranged in a line on the right side, and it will be seen that they drive both up to the shaft and horizontally to the dynamos. In this connection the method of safeguarding the attendants when they have to pass under the belts is worthy of notice. Metal screens forming short tunnel ways have been provided, these being some 6ft. high by 4ft. wide. To each side of them are attached the hand rails guarding the fly-wheels and the belt races. We may also direct attention to the overhead runways and to the lifting tackle working on these. At the far end of the room will be seen an air compressor for the pneumatic tools used throughout the works. This is belt driven from the gas engines through the main shaft and a countershaft.

A most successful portion of the undertaking has been the clutches connecting the belts to the main shafting. In order to deal with the heavy strains put on these main driving pulleys by the cyclic variation of the gas engines, the former were carried on specially designed quill bearings carried in brackets independently of the main shaft. The power is transmitted from the pulleys to the shaft through specially designed self-centering clutches. A sectional illustration of the whole arrangement will be found in Fig. 1. We carefully examined the working of these clutches, and made inquiries as to their behaviour. Owing to the pulley being independent of the shaft, there has, so we understand, been no trouble whatever, and in view of the difficulties which surround the transmission of large powers through clutches, this must be considered most satisfactory.

Before passing on to a description of the electrical portion of the equipment, we may usefully refer once more to the producers and engines, and see how these fulfilled the specified conditions under which they were ordered. The guaranteed consumption of Scotch anthracite was:—

Full load	1lb.	per brake horse-power hour.
Three-quarter load ...	1¼lb.	" " "
Half load	1½lb.	" "

The jacket-cooling water for the gas engines was to be from 3½ to 5 gallons per brake horse-power hour, and for the scrubbers and gas generators not more than one gallon per brake horse-power hour for both purposes. We may say that the water used is taken from the exhaust from the hydraulic services throughout the works. This water is collected in an equaliser tank which is fixed above the gas plants by the side of the coal bunkers, and may be seen in Fig. 5, page 619. The hot water from the jackets is carried to the feed-water tank of the steam boiler in the smiths' shop.

The behaviour of the various portions of the plant is well shown in the tables on the next page, which give the results of the official trials run last February. From Table I. it will be seen that each of the engines A, B, C, and D ran 10½ hours on February 25th last, and that the average amount of coal used per brake horse-power hour was ·854 lb. As one engine was running at less than half its specified brake horse-power, and as neither of the four was working to its full capacity—the average being 117·65 brake horse-power—this is as a consumption well within the guarantee. In Table II., which shows the results obtained on the next day, February 26th, the powers were higher, the average being about 136 brake horse-power per engine. In this case the consumption of coal worked out at ·845 lb. per brake horse-power per hour. The total water consumption per brake horse-power hour, including jackets and producer, was 4·2 lb. in the first test and 3·64 lb. in the second test.

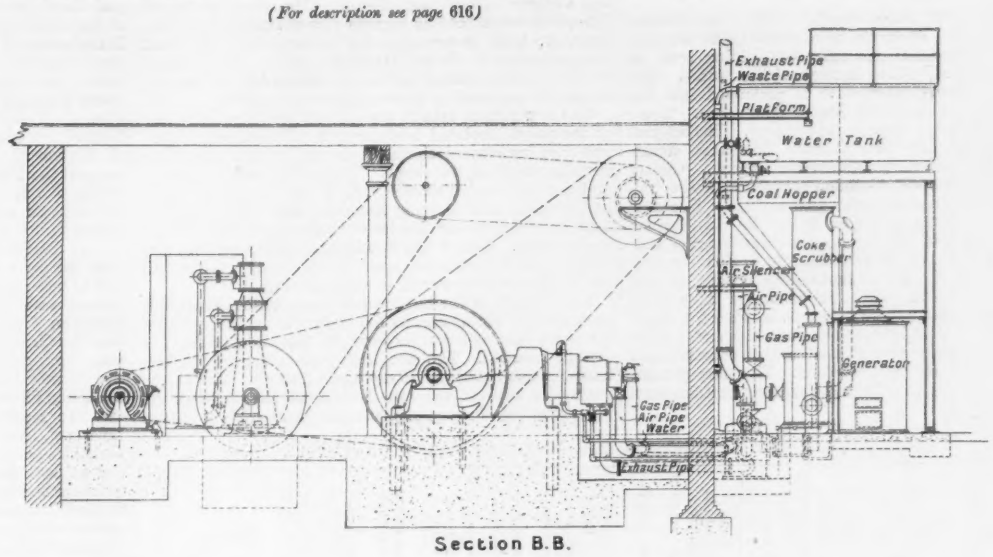
Table III. shows the results over a more prolonged period, the details of which are given. In this case the total coal consumption per brake horse-power hour, including stand-by losses, &c., worked out at ·973 lb., while the water consumption was approximately the same as in the foregoing tests. The brake horse-power, we may mention, includes the power necessary to drive the main belts on their loose pulleys of the countershaft, and also that to run the dynamos belted to engines A, C, and D, engine B not generating any current. The consumption figures are therefore even better than they appear. The indicated horse-power of gas engines are unreliable figures to go by, but we may mention that in this case the total consumption of coal per indicated horse-power, as shown by indicator diagrams, was ·73 lb.

The foregoing results show that the plant is evidently working within its guarantee, and they afford ample justification for the drastic step which was taken by Messrs. Rowan in changing from a steam engine to a gas plant. No marine engine of 600 horse-power would give a brake horse-power hour, including stand-by losses, for ·973 lb. of coal, not to mention

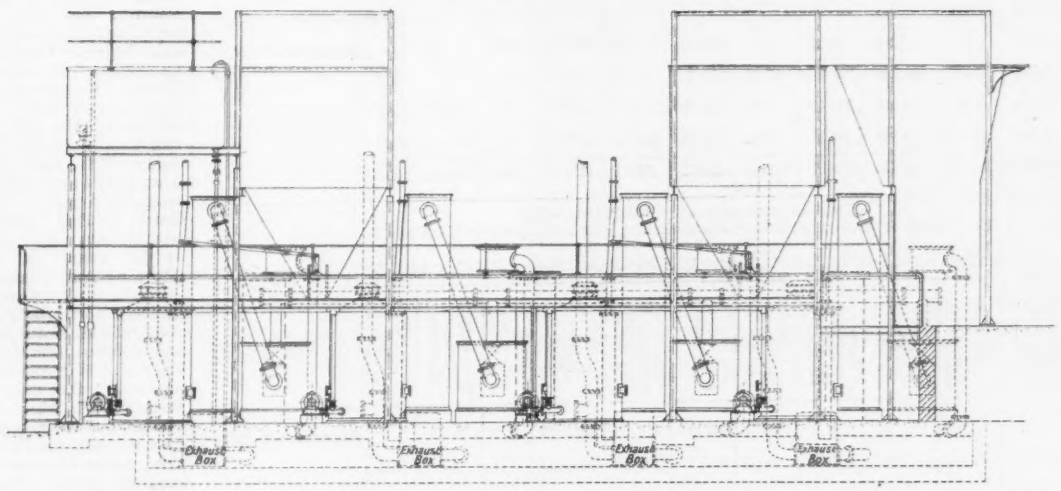
* See "Proceedings" of the Institution of Mechanical Engineers, September, 1901. No. 4, page 959.

GAS POWER PLANT AT AN ENGINEERING WORKS

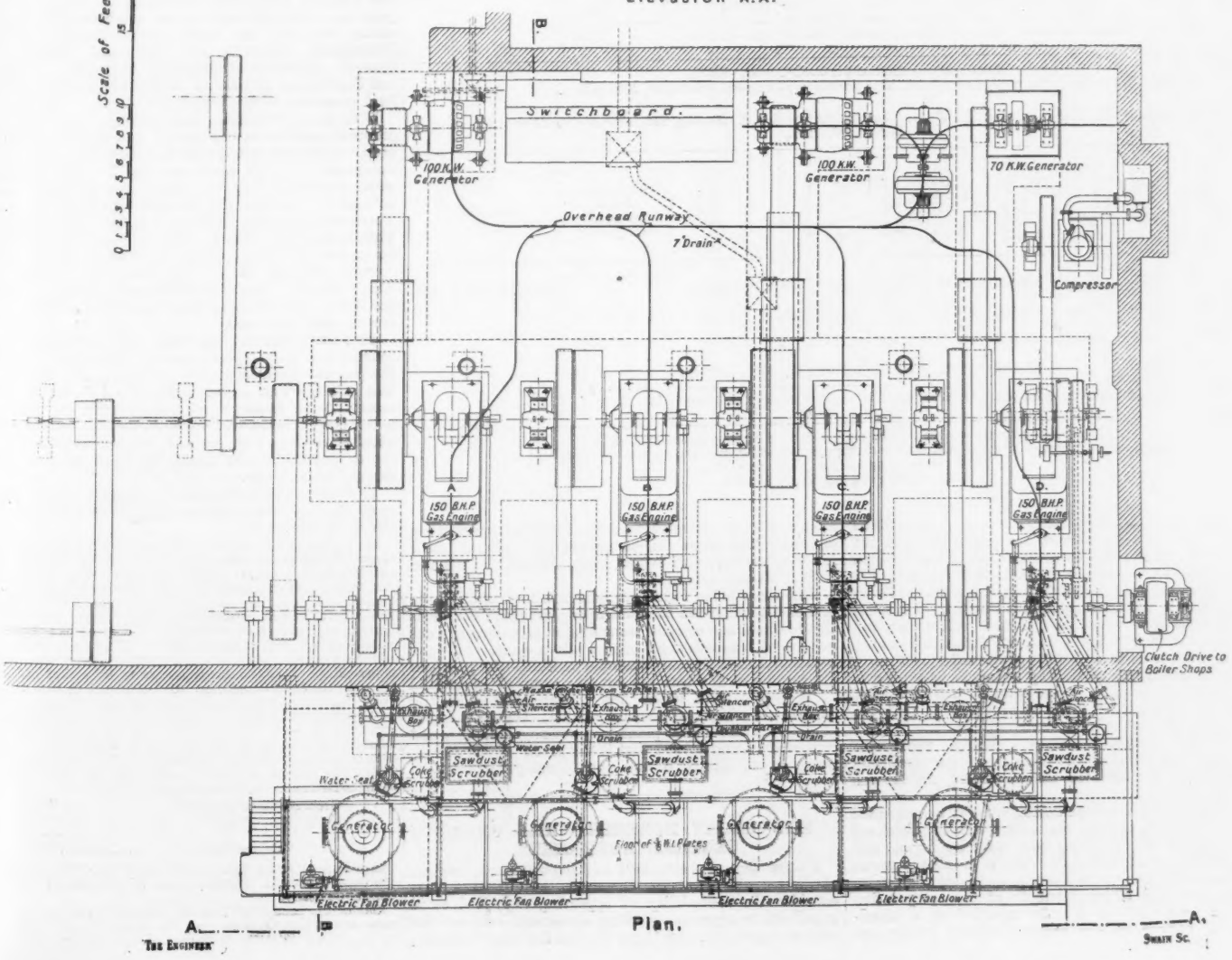
(For description see page 616)



Section B.B.



Elevation A.A.



Plan.

"THE ENGINEER" SMITH SC.

·845 lb., even under the most favourable conditions. It may be added that the Scotch anthracite (doubles) was from the Barblues Colliery, and that it cost 18s. per ton at the time of the test.

It was decided, we think wisely, to drive the electric generators by belt. It should be explained that the electric current is required not only for lighting but for driving a number of motors throughout the works. The main shafting already referred to is prolonged into the works and itself drives a good deal of machinery. There are, however, as many as 42 electric motors. The original motors obtained their current from Schuckert shunt-wound dynamos driven from the steam engine. One of these dynamos has been re-wound compound, and equalised, and is belted to one of the gas engines. Two new generators were put in, each also driven by belt from a gas engine. Each of these generators has a rated output of 100 kilowatts at 650 revolutions per minute, and each is designed to give a continuous output of 910 ampères at 110 volts. The field windings have been specially compounded and equalised to balance the cyclic variation of the gas engines, and the machines are said to work quite sparklessly with a fixed line of commutation from no load to 50 per cent. overload. The new generators were supplied by the Electric Construction Company, of Wolverhampton.

lighting plant was 110, and it was decided that it would be cheaper to adhere to this voltage than to carry out the alterations which would have been necessary had a higher voltage been chosen. The whole of the old 110-volt service, both as regards power and lighting, has, however, been re-arranged, the contract for this work being awarded to Messrs. Haddow and Co. The contract for the electric lighting and power mains, &c., for the new works was secured by Messrs. Hunter and Jack.

The new mains, both in the old and new buildings, are of the paper insulated lead-covered and armoured type, and they are cleated to the walls and to the steel construction work of the shops. The wiring for the lighting and the leads to the motors, &c., is run from the distributing board and starting switches with 2500 megohm C.M.A. grade rubber insulated cables in thick screwed steel tubing. One of the distributing switches and fuse boards, which have been specially designed to withstand the rough usage of works, is shown in Fig. 2.

The lighting of the new part of the works is carried out by means of double carbon flame arc lamps, the contract for these having been obtained by the Brockie Pell Arc Lamp, Limited. The arc lights are slung above the travellers, so that they do not get damaged. It was the particular wish of the late Mr. James Rowan that the lighting of the shops at night should practically equal that

TABLE I.—*Trial of* 600 *B.H.P. Suction Gas Power Plant, Monday 25th February*, 1907.

Engine and gas plant.	Time of running.	Number of explosions during run.	Mean number of explosions per minute.	Number of revolutions during run.	Mean number of revolutions per minute.	Mean pressure in cylinder.	Mean I.H.P.	Mean B.H.P. of engine.	B.H.P. hours.	Units generated, watts.	Mean output of kilowatts.	Coal consumed during test.	Remarks.
												lb.	
A	10½	43,788	69·5	106,580	169·16	80·7	168·94	126·28	1325·94	685	65·24	—	Generator not working
B	10½	29,438	46·72	107,040	169·9	85·78	120·7	68·75	721·87	—	—	1093	
C	10½	42,405	67·31	106,590	169·19	89·06	180·57	138·89	1458·34	685	65·24	1792	
D	10½	42,430	67·35	106,960	169·8	88·92	180·34	136·69	1435·24	435	41·42	1336	
Totals	42	158,061	250·88	427,170	678·05	344·46	650·55	470·61	4941·39	1805	171·90	4221	

Total coal consumption per B.H.P. hour, ·854 lb.
Total water consumption per B.H.P. hour (including jackets and generator), 4·2 gallons.

TABLE II.—*Trial of* 600 *B.H.P. Suction Gas Power Plant, Tuesday, February 25th*, 1907.

Engine and gas plant.	Time of running.	Number of explosions during run.	Mean number of explosions per minute.	Number of revolutions during run.	Mean number of revolutions per minute.	Mean pressure in cylinder.	Mean I.H.P.	Mean B.H.P. of engine.	B.H.P. hours.	Units generated, kw. hours.	Mean output of dynamo, kilowatts.	Coal consumed during test.	Remarks.
												lb.	
A	11½	43,725	63·36	117,342	170	84·34	160·93	123·26	1417·49	819	71·21	—	Generator not working
B	11½	39,282	56·93	117,840	170·72	83·92	143·9	101·16	1163·34	—	—	1605	
C	11½	56,346	81·66	117,225	169·83	83·78	218·68	184·01	2116·11	772	67·13	1925	
D	11½	43,554	63·12	118,523	171·76	90·14	171·38	135·56	1558·94	—	—	1760	
Tota's	46	182,907	265·07	470,934	682·36	347·18	694·92	543·99	6255·88	—	—	5290	

Total coal consumption per B.H.P. hour, ·845 lb.
Total water consumption per B.H.P. hour (including jackets and generator), 3·64 gallons.

TABLE III.—*Trial of* 600 *B.H.P. Suction Gas Power Plant lasting from 7 a.m. Monday, 25th February, to 12 noon Saturday, 2nd March*, 1907.

Engine and gas plant.	Time of running.	Number of explosions during run.	Mean number of explosions per minute.	Number of revolutions during run.	Mean number of revolutions per minute.	Mean pressure in cylinder.	Mean I.H.P.	Mean B.H.P.	Total B.H.P. hours.	Total amount of coal consumed during week.	Remarks.
										tons cwt. qr. lb.	
A	88½	375,935	70·8	899,962	169·48	82·52	176	135·82	12,020·7	—	Generator not working
B	63½	192,974	50·65	661,620	173·65	84·85	135·5	88·16	5,598·16	4 17 0 13	
C	101	378,310	62·43	901,870	148·82	88·92	167·2	128	12,923	6 4 2 23	
D	42	169,020	67	429,902	170·6	89·53	180·7	140·97	5,920·74	4 15 0 11	
Tota's	295	1,116,239	250·88	2,893,354	662·55	345·82	659·4	492·95	36,466·9	15 16 3 19	

Total coal consumption per B.H.P. hour (including stand-by losses, &c.), ·973.
Total water consumption per B.H.P. hour (including jackets and generator), approx. same as above.
Total coal consumption per I.H.P. hour, ·73.
NOTE.—Coal used, barblues anthracite.

In Fig. 4, page 619, will be seen the switchboard, which is arranged on the other side of the engine-room to the gas engines. To the bus-bars on this switchboard, which is well designed and made, each generator is connected in parallel, the load being automatically distributed between the machines by means of equaliser switches. We spent a considerable time watching the main volt meter, and in spite of the fact that the load on the three dynamos was varying considerably and continually, the main voltage remained extraordinarily constant and regular. The maximum variation in the voltage was not more than 2 per cent., and it must be remembered that the motors throughout the works were all the time varying the demand for current within wide limits. This result speaks well not only for the working of the equalising arrangements, but also for the governing of the gas engines.

The right-hand side of the switchboard is arranged for a 500-volt service, used in connection with the overhead cranes, which, we may add, were built by Royce and Co., Limited, of Manchester. There is also a motor generator which can receive 500 volts and deliver 110 volts. In this case the 500-volt supply of the corporation is drawn upon, but it is only regarded as a stand-by. The voltage of the original electric power and of daylight, and although we did not have an opportunity of testing this ourselves, we understand that this effect has very nearly, at all events, been obtained by the use of these flame arc lamps.

The whole plant forms an interesting example of the economies which can be effected by a judicious combination of direct and electric transmission of power in connection with a modern gas engine power plant. As far as we know, this is the only example in which four producer gas engines of this size are running coupled in parallel at the same time to the line shafting and to electric generators, which are also in parallel. On the occasion of our visit the whole plant was working smoothly and well, and we understand that it has given satisfaction in every way to Messrs. Rowan since it was put to work.

THE GREAT NORTHERN AND GREAT CENTRAL AGREEMENT.

TO-DAY there is being held at King's Cross a meeting of the proprietors of the Great Northern Railway "to consider the desirability of approving and, if deemed expedient, to approve a working agreement between the said company and the Great Central Railway Company, in pursuance of the Great Northern and Manchester, Sheffield, and Lincolnshire Railway Companies' Act, 1858. This agreement is subject to the approval of the Railway and Canal Commissioners and of the proprietors of each of the said companies." A meeting is also being held at Manchester of the Great Central shareholders for the same purpose. The history of the relations between these two companies is very interesting. For many years they were allies, and particularly in the through service between King's Cross and Manchester, *viâ* Retford, in which was run one of the celebrated trains of the world—the 2 p.m. from King's Cross—which covered the 203 miles to Manchester in 4¼ hours. The relations were severely strained, however, by the independent advent of the Great Central into London. Powers for this were obtained, after three severe fights in the Parliamentary Committee rooms, in 1893. In 1897 the name was changed from Manchester, Sheffield and Lincolnshire to Great Central, and the London extension was opened throughout in 1899. The Great Northern then began to exercise its running powers over the Great Central line to Sheffield and Manchester, and, consequently, there was competition between the two former allies for traffic to and from Nottingham, Sheffield, Huddersfield, Bradford, Wakefield, Leeds, York and the North-Eastern—*viâ* Rotherham—Manchester, Liverpool, and Lancashire, and the West Riding of Yorkshire generally. Strangely enough, most of this traffic had to pass through the Victoria Station, Nottingham, which is the joint property of the Great Northern and Great Central Companies. At one period the Great Northern made a very good bid to retain the Sheffield and Manchester traffic, but, possibly anticipating future events, it has modified its service. Its up afternoon express, however, does the 161¼ miles between Sheffield and King's Cross in 2 h. 58 min., and is the fastest timed train between Grantham and London—105¾ miles in 1 h. 50 min. The down evening train gets to Sheffield in 3 hours. Both the Midland and Great Central take the same time for their best down trains, the former with a mileage of 158¼ miles, and the latter with 164¼. But whilst it is natural that the Great Northern should feel the loss of the traffic the Great Central was able to divert, it is possible and probable that the Midland has felt the competition more. The latter company found that the Great Central timing between London, Leicester, Nottingham, and Sheffield was almost as good as its own. In addition to carrying the war into the enemy's camp in this way, it went further, and started a fine cross-country service from Newcastle, York, and the North-Eastern line, Manchester and Bradford *viâ* Sheffield, Nottingham and Sheffield to Southampton and Bournemouth over the Great Western and London and South-Western lines. Prior to this the Midland had practically the only route between the North and Bournemouth, which it handled very well over its own system, but the progress over the Somerset and Dorset joint line between Bournemouth and Bath was somewhat slow, owing to most of the line being single and the gradients severe. There are, however, now half a dozen express or fast trains over the joint line, and luncheon cars between Derby and Bournemouth. Then, above a year ago, a through service was established from Newcastle, York, and the North-Eastern line, *viâ* Sheffield, Nottingham, Leicester, and the Great Western line through Banbury, Cheltenham, Gloucester, Newport, and Cardiff, and *vice versâ*. This was invading the Midland preserves with a vengeance.

With these preliminary remarks let us come now to the proposed agreement. It should first be noted that it is proposed to carry out the terms of the Act of 1858, which sanctioned such an agreement for fifty years, a term which expires on July 23rd next. It arose out of a fight between the London and North-Western and the Great Northern for traffic between London and Lancashire, Yorkshire, and the North. The Midland was conciliated for surrender of its opposition by being given running powers over the Great Northern from Hitchin into King's Cross. The North-Western, however, opposed the Bill in both Houses, but unsuccessfully, and it became law on July 23rd, 1858.

That the intention is to work both companies as one concern is evident from a recent remark of Mr. Sam Fay, the General Manager of the Great Central. He said he was satisfied that never would the shareholders have reason to be better pleased, never would the public be better served, and never would the staff be better off than when, if it was at all possible, no man would be able to see or say where the Great Northern ended and the Great Central began.

The following is a copy of the circular issued to the proprietors as to the terms of the agreement to be considered to-day :—

The working agreement between the Great Northern and Great Central Companies is made in pursuance of the Great Northern and Manchester, Sheffield, and Lincolnshire Railway Companies Act, 1858, which authorises the two companies to appoint a Joint Committee for carrying into effect the purposes of the agreement. The Joint Committee appointed by the agreement are in the first place to be composed of the Great Northern and the Great Central directors. With the exception of the Lancashire, Derbyshire, and East Coast Railway and the Sheffield District Railway, the undertakings of the two companies are to be worked and maintained by the Joint Committee. Out of the net receipts for each year, after allowing to each company interest at the rate of 3½ per cent. per annum on the duly authorised capital expended or to be expended by such company from the 1st January, 1907, the Joint Committee are to pay the sum of £3,803,332, to the two companies in proportion to their net receipts for the year 1906.

The net receipts of the two companies for 1906—subject to slight adjustments—have been agreed as follows :—

Great Northern Company	£2,168,303
Great Central Company	1,635,029
Making together	£3,803,332

and giving—in round figures—the proportion of 57 per cent. to the Great Northern Company, and 43 per cent. to the Great Central Company.

Out of the balance of the net receipts, if and so far as the same are sufficient in each year, the Great Central Company are to be allowed £100,000 in respect of the capital expenditure by

GAS POWER PLANT AT AN ENGINEERING WORKS

(For description see page 616)

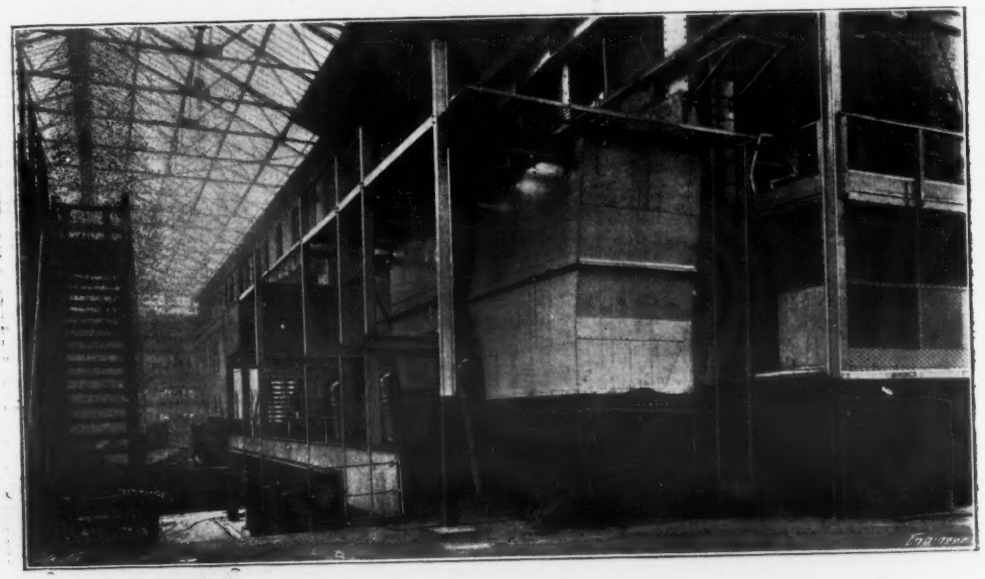


Fig. 3—COAL BUNKERS OF GAS PRODUCERS

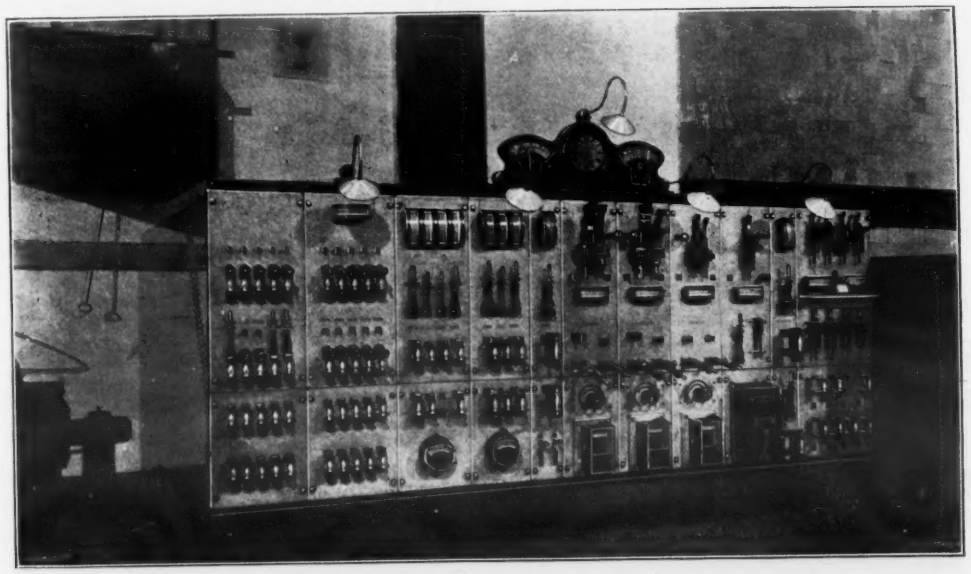


Fig. 4—SWITCHBOARD

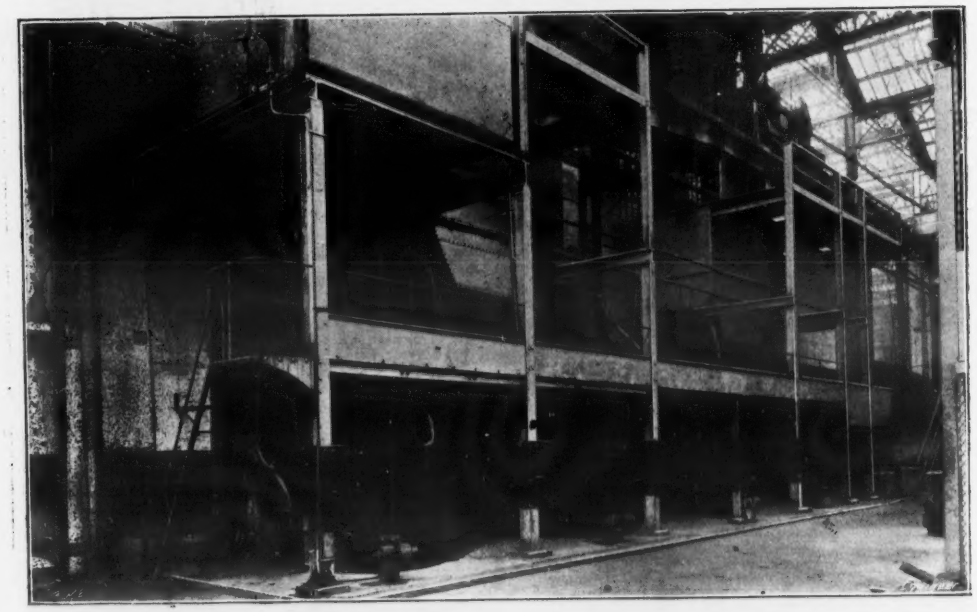


Fig. 5—THE GAS PRODUCERS

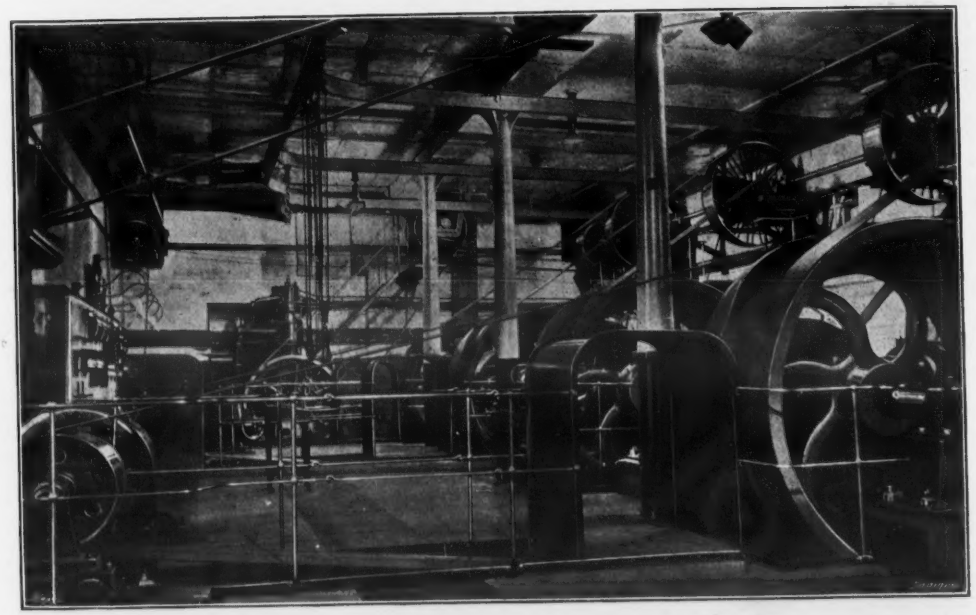


Fig. 6—THE ENGINE ROOM

them on certain new lines and works which had not fructified in the year 1906.

The residue of the net receipts, after the payments before mentioned, is to be divided between the two companies in the following proportions:—

Down to and including the year 1910—57 per cent. to the Great Northern Company and 43 per cent. to the Great Central Company.

After the year 1910 and down to and including the year 1912—56½ per cent. to the Great Northern Company and 43½ per cent. to the Great Central Company.

After the year 1912—56 per cent. to the Great Northern Company and 44 per cent. to the Great Central Company.

The agreement does not seek to alter the constitution of any joint undertaking in which either of the companies are interested, nor does it affect the capital powers of the two companies.

The agreement is to come into operation as soon as it has received the approval of the proprietors of each company and of the Railway and Canal Commissioners.

The larger proportion that is allotted to the Great Northern is, no doubt, its due. It has a magnificent traffic to Leeds, York, Newcastle, Edinburgh, and Scotland, and a valuable suburban traffic in the London district and Yorkshire. On the other hand, the Great Central can bring the immense traffic of Lancashire and the Sheffield district, besides having spent vast sums under the *régime* of Sir Alexander Henderson, the present chairman, in widenings and new works, and on its engines and rolling stock—than which there are few if any better in the country. The proportions are, therefore, in our opinion, very fair.

The agreement, even if the proportions were considered unfair, is nearly sure to be approved by the proprietors, because, owing to the savings that may be effected, the profits are bound to be higher. It will then have to be submitted to the Railway and Canal Commission for approval. This is in accordance with the Railway Clauses Act of 1863—26 and 27 Vict., cap. 92—Part III. of which provides for two or more companies agreeing amongst themselves as to:—(*a*) The maintenance and management of the railways of the companies respectively, or any one or more of them or any part thereof respectively, and of the works connected therewith respectively, or any of them; (*b*) the use and working of the railways or railway, or of any part thereof, and the conveyance of traffic thereon; (*c*) the fixing, collecting, and apportionment of the tolls, rates, charges, receipts, and revenues levied, taken, or arising in traffic. After stating that such an agreement must be submitted to the proprietors of the several companies thereto, and notice of their intention to enter into such an agreement shall be published in the newspapers, setting forth within what time any company or person desiring to object may do so, the Act states that "the agreement shall not have any operation until it is approved by the Board of Trade, and the Board of Trade shall not approve the agreement without being satisfied of its having received such sanction of the respective companies as aforesaid." Joint committees are sanctioned which may exercise the powers hitherto exercised by the companies or their directors. The Act further provides that at the expiration of the first or any subsequent period of ten years after the making of the agreement, the Board of Trade may, if they are of the opinion that the interests of the public are prejudicially affected thereby, cause the agreement to be revised. By the Regulation of Railways Act, 1873, 36 and 37 Vict., cap 48, the Railway Commissioners were appointed, to whom were transferred, *inter alia*, the powers under the Act of 1863 as to agreements. In 1888, under the Railway and Canal Traffic Act, 51 and 52 Vict., cap. 25, the then Commission was abolished and a new one was sanctioned of two appointed and three *ex officio*—one for England, one for Scotland, and one for Ireland. The Commissioners for England are Mr. Justice Bigham, the Hon. A. E. Gathorne-Hardy, and Sir James Woodhouse. The following is the notice that has to be inserted in the newspapers:—"Notice is hereby given pursuant to the provisions of the Railway Clauses Act, 1863, and the Railway and Canal Traffic Acts, 1873 and 1888, and the . . . . Act, 18 . ., that it is the intention of the . . . . Railway Company and the . . . . Railway Company to enter into an agreement for the following purposes, viz. (amongst other things), the . . . . and that any company or person aggrieved by such proposed agreement, and desiring to object thereto, may bring such objection before the Railway and Canal Commissioners by sending the same in writing to the Registrar to the Railway and Canal Commissioners at their office, at the . . . . , London, on or before the* . . . . day of . . . . 18 . . , in which office a copy of the proposed agreement can be seen."

[* Twenty-eight days should intervene between the date of the newspaper containing the first insertion of this notice and the date here inserted.]

Whether any of the public will enter a protest is uncertain. It is hardly likely that any individual or firm can be "aggrieved" by the proposed agreement. The railway companies are different. The London and North-Western and the Midland are sure to protest, but we cannot see how the proposals can be modified. We await with much interest the conclusion of the matter, and trust that brighter days are in store for the Great Northern and Great Central Companies.

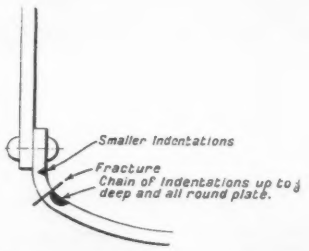
THE GREENWICH BOILER EXPLOSION.

A YEAR ago to the day a thermal storage tank at the works of the South Metropolitan Electric Lighting and Power Company at Greenwich exploded. It was one of four similar drums, and the circumstances were so remarkable that, after the coroner's inquest on the bodies of two men who lost their lives, the matter was adjourned until further light could be thrown upon the accident by scientific examination of the steel of which the drum was constructed. This evidence being now obtained, a Board of Trade inquiry was opened at Greenwich Town Hall on Monday last, and is not yet concluded.

It opened with a recital of the history of the drum and of the accident. The drum was made by Babcock and Wilcox, and was one of a pair connected with one of their boilers; it was used in the usual way for supplying hot feed to meet the peak load. It was 5ft. in diameter by 22ft. 6in. long. It had dished and flanged ends ⅞in. thick, riveted into the barrel, which was ¾in. thick. Near the right-hand bottom side of one of the drum ends, and right at the knuckle of the flange, a slight leakage of steam became evident after the boiler had been at work only a few weeks. The leak on examination was found to issue from a hair crack 2 7/16 in. long, which was not considered serious by various persons who examined it. It was, however, under observation, and whilst a boiler inspector was examining it the end was blown out of the drum, and the drum itself was projected 95 yards backwards, demolishing two walls in its flight. There were 3ft. of water and 160 lb. pressure in the boiler at the time. The fracture took place circumferentially through the dished end at the knuckle of the flange, and thus a complete disc was blown out. On examination by a Board of Trade inspector the opinion was formed that a circumferential crack had existed for some time. The end plate was cut in two, and one part was sent to the National Physical Laboratory for complete examination and test. The end of another sound drum was removed by the makers, and also subjected to tests.

Part of the exploded end plate was exhibited at the inquiry. It is remarkable on account of the fracture, and because of a series or "chain" of indentations, as they were described, which exists all round the plate at a short distance from the knuckle; their position in section through a single indentation is indicated in the annexed sketch, and they were described as being up to about 1in. diameter by ⅛in. deep. The adjacent indentations in many places touch each other. A great deal of the evidence taken on the first day turned on the importance and cause of these indentations.

The first witness was Mr. Bowden, chief engineer to the Electricity Company. The boiler, he said, had been tested to 230 lb. hydraulic pressure, and put to work in August, 1906. There were never any symptoms of trouble with water hammer. When he examined the crack in the end plate it appeared to be about ¾in. long, but later when a microscope was brought to bear, it was found to be 2 7/16 in. It was extremely fine, and was evidenced by a small leakage of steam from it. On examination on the day following the explosion he observed that about half the fracture was discoloured, from which he deduced that a crack on



SKETCH SHOWING INDENTATIONS—EXAGGERATED

the inside of the plate, and extending possibly halfway through, had existed for some time; he could give no idea how long. There were two kinds of marks or indentations on the plate. One, occasional marks, probably made by the rivet snap to which he attached no importance; and the other, the "chain of indentations," which he did regard as important, because he thought the metal must be distressed locally by the means producing them. The opposite drum head, which had been turned nearly inside out by impact with brick walls, showed similar marks, but he thought they were less severe. Examined by Mr. Hallett, of the Board of Trade, who was assisting the commissioner, Mr. Bowden expressed the opinion that in the course of manufacture it was found that the end of the drum did not fit the barrel, and the flange was pressed or worked out cold to the required diameter.

The rest of the evidence on Monday was given by inspectors and boilermakers, and bore out Mr. Bowden's statement, save that there was some difference of opinion as to the precise position and direction of the initial crack, Mr. Bowden holding that it took an inclined, whilst Mr. Cobell, erector for Babcock and Wilcox, Limited, thought it was circumferential. All the evidence was to the effect that no one considered the crack serious, and did not think any danger was to be anticipated from it.

The proceedings on Tuesday were of little or no scientific interest. Most of the time was occupied in the examination of one of Babcock and Wilcox's out-door superintendents of erections, who was engaged in other work for the electricity company at the time and examined the crack. Cross-examination appeared to be directed to prove that he was a responsible person, and should have advised the shutting down of the boiler and thermal storage tank. He was followed by Mr. Kolle, assistant engineer to Babcock and Wilcox, whose examination took nearly the whole of Wednesday. He said that out of a total of 3695 drum ends only ·57 per cent. developed any defect during dishing, and practically all such defects were discovered before the ends were riveted into the drums. The plates for the thermal storage drum in question were made by Beardmore's, and the tests of them were witnessed by Lloyd's. He judged by the appearance of the fracture that the ruptured plate was brittle. He took this view from the crystalline formation of the metal at the break, and the fact that a crack nearly ⅞ of the circumference had, as shown by discoloration, existed in the plate for some time prior to the explosion. He noticed the chain of indentations, but did not consider them of importance in connection with the explosion. It was the first failure of a drum end in the history of the company. He had, he believed, seen similar indentations to those in the ruptured end, but up to the time of the explosion neither his firm, nor insurance companies by whom their boilers were inspected, had attached any importance to them; but now that attention had been called to them the insurance companies expressed a wish that such indentations should not occur, and alterations to some existing drums had been made at the request of the companies, in some cases by the owners themselves, and in some by Babcock and Wilcox. The alteration consisted in the provision of stays. The steel used for the drums was specified to have a tensile strength of from 24 to 28 tons, with a minimum elongation of 20 per cent. in 10in., and Lloyd's found actually a tensile strength of between 26·9 and 27·1 tons with an elongation of 25 per cent. The tests were, therefore, eminently satisfactory. Questioned on the chain of indentation, the witness said he thought they were produced in the hydraulic riveting press by the shoulder of the snap head, and whilst they showed some crushing and distortion he did not think the damage was sufficient to affect the plates detrimentally. At the other end of the same drum he had found similar indentation, which appeared to him to differ little if at all from those on the broken end.

At this point letters by Mr. Rosenthal, the managing director of Babcock and Wilcox, Limited, and Mr. Spyer, his assistant, were read. The letters were intercommunications between the London office and the Renfrew works of the builders. Mr. Rosenthal suggested that the crack was due to a bubble or flaw in the original plate which was rolled flat and closed by a thin external skin. He wrote also on the subject of the process of manufacture of the drum ends, and asked if they were annealed after pressing. Mr. Spyer in his letter expressed the opinion that the plate was extremely hard, and that a defect not shown by the mechanical tests existed in it. Mr. McLaren, the manager at Renfrew, in reply to Mr. Kolle, said that the end plates were dished at one heat, and then reheated for the production of the manhole, and they were then allowed to cool slowly. The reheating for the manhole he regarded as equivalent to annealing. He did not think exception could be taken to this method, and mentioned that it was a common practise in flanged work to heat a plate locally and work upon it. The indentations, he thought, were caused by the snap, but they should not have extended beyond the cylindrical part of the dished end, but since the defect was internal he could not see how internal indentation could affect it.

Mr. Kolle, further examined, said that in order to prevent indentation in the future the lands were now being made larger. He did not consider that such indentations as those constituting the chain would have an injurious effect on a normal plate, and he was supported in this view by the fact that there were no fractures in the plate, similarly indented, at the other end of the drum. At the Renfrew works over forty men were engaged upon inspection to see that every part was of the highest material and workmanship before it left the works, and it was the business of outside erectors only to put together the parts they received. If they, Babcock and Wilcox, would not now allow indentations, it was not because they themselves regarded them as injurious, but because other people objected to them.

Mr. Spyer, chief of the Marine Boiler Department and assistant to the managing director of Babcock and Willcox, Limited, was then called. He admitted that from the mechanical tests the material appeared to be quite good, and he described the appearance of the fracture when he saw it the day after the explosion; he noticed the signs of an old crack extending nearly five-eighths of the circumference, and the "chain of indentations," which puzzled him at the time. The fracture had started from the inside, and had, generally speaking, followed the chain of indentations. Such indentations should not, in a normal plate, materially affect its ductility, and if they did so in this case it would only be to a small extent. He thought that slight surface cracks which had extended with extraordinary rapidity to the outside had existed initially in the plate. These cracks were on the inner surface near the indentations, and on the dome side. Asked by the Commissioner to define a normal plate, he said it was one that would stand a fair amount of knocking about, and he would use as tests tensile, elongation, bending, and in some cases hammering. He came, as a result of his examination, to no decision as to the cause of the explosion. He was much puzzled, and agreed with Mr. Rosenthal that it showed so many curious features that an independent engineer should be called in.

Mr. Spyer's evidence was not concluded when the inquiry was adjourned till the following day—Thursday.

The inquiry is making very slow progress, and there is no likelihood of its being concluded before Christmas. It will, at the time we go to press, have occupied four days, and the evidence of the experts has yet to be taken

FATAL RAILWAY COLLISIONS.

WITHIN the last few days there have been issued from the Board of Trade the reports on these collisions, in two of which a member of the locomotive department staff was killed. They are both of interest to readers of THE ENGINEER, as confirming the views contained in the editorial columns of the issue of November 22nd, as to its being in the "man" and not the "machine" that the contributory cause to railway accidents now lies. In order that the situation in each case may be the better understood, there are appended, in Figs. 1, 2, and 3, diagrams of the lines and signals which have been prepared from the "description" in the Board of Trade reports.

The first collision was at Kilrain, on the Great Southern and Western of Ireland. This is the first station after leaving Rosslare Harbour, and a diagram of the lines, &c., is given in Fig. 1. It is situated on a single line as shown, with a loop

which may be used for goods trains and light engines, but not for passenger trains. On the night of September 18th last an empty passenger train from Rosslare Harbour direction was offered to, and accepted by, the signalman at Kilrain, and immediately afterwards he accepted a light engine from Wexford. The man was authorised by rule to do this, providing he kept his signals at danger and pulled both trains up. When they had come to a stand the rule provides that the train that is to be first admitted into the station may proceed, and that, after it has again come to a stand, the signals may be lowered for the second train if the line be clear. The Kilrain signalman, however, thought that there was time for the empty coaches to get to the platform before the light engine arrived, and therefore he lowered his up

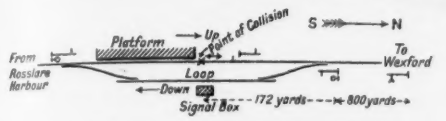


Fig. 1—SCENE OF THE KILRAIN ACCIDENT

home signal, and the train entered and came to rest at the station platform. Whilst a rule was being broken by this action, the operation might have been protected had the signalman placed his facing points at the north end so as to lie for the loop and thus to turn the light engine should it overrun its signal. Kilrain, however, is not interlocked on modern lines as the points leading into the loop at the north end are interlocked with the up home signal. Present-day interlocking allows the home signal to be free, but the up starting signal must be at danger, and consequently the distant is "on."

Meanwhile the light engine was approaching from Wexford. There was a fog at the time, the evidence as to the density of which is conflicting. It was probably a rolling fog, and at the time the collision occurred it must have been dense, as the men on neither engine saw the other engine until the collision actually occurred. Owing to this, and no fogmen being out, the men on the light engine missed the distant signal, and when the driver sighted the home signal he

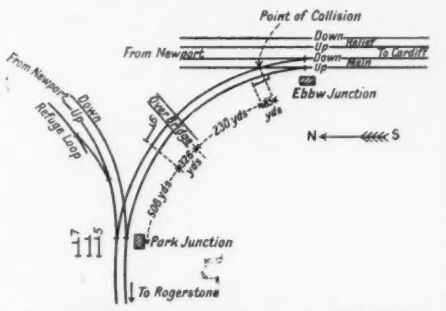


Fig. 2—SCENE OF EBBW JUNCTION ACCIDENT

assumed for the moment that it was the distant, but as soon as he passed over the points he knew where he was and applied the vacuum brake fully. He did not reverse his engine, as he was looking towards the signal-box for the signalman to give him the tablet to proceed towards the harbour, but when he saw nothing of the man he knew something was wrong, so reversed, but too late, as the collision occurred, and a locomotive foreman who was riding on the light engine received such injuries that he subsequently died. These, then, are the reasons for this fatal collision, which must be included amongst the avoidable accidents:—Breach of block working by the signalman; absence of up-to-date interlocking; no system of fog-signalling. There was also a contributory cause in that there was no lamp provided for the disc signal for entering the loop, an omission for which the station officials were to blame.

The second collision was due to an inadvertent action on the part of a signalman, and was more in the nature of an accident. It occurred on the Great Western main line at Ebbw Junction on September 20th.

Fig. 2 gives an idea of the locality. A mineral train from Rogerstone for Cardiff direction arrived at Park Junction, and as the Ebbw Junction signalman refused to accept it, it was allowed to draw forward to the starting signal worked by No. 6 lever, and in order to remind himself of the train the man put, or imagined he put, a leather collar over No. 6 lever and No. 5 lever working the home signal. Whilst standing there a second mineral train arrived which had to go towards Newport. As the signalman at the next signal-box in the direction of Newport refused to accept the second train, and as a passenger train was due, the man at Park Junction set his points to turn the second train into the refuge loop and then lowered, as he thought, No. 7 signal for the train to go into the loop.

About this time an express passenger train was approaching Ebbw Junction on the up main line, and at the intersection of the line from Park Junction with the up main line the engine of the express train met the engine of the mineral train, with the result that the driver of the latter was killed. The reason the latter train was at the junction was soon discovered, and it was seen that the signalman at Park Junction had pulled over No. 6 lever and lowered the starting signal at which the mineral train was standing instead of No. 7 lever for the home signal into the refuge loop. As there is a regulation that trains must not be allowed to leave the starting signal unless there be a clear road at Ebbw Junction, the unfortunate driver was led into a trap, and he was prevented from pulling up by having a train of 48 wagons and 2 brake vans, of which only one, weighing 13 tons 2 cwt., was in use, so that he had only the engine brake—80 per cent. of the load of 56 tons 4 cwt.—and the one brake to assist him with a load of 815 tons, and this on a falling gradient of 113 yards of 1 in 62, 198 yards of 1 in 70, and 176 yards of 1 in 129. The last 110 yards are level. Added to this, the view of Park Junction home signal is obstructed by an overbridge. The signalman at Park Junction took all the blame for the accident, and it is presumed that he had put the collars on Nos. 4 and 5 levers instead of Nos. 5 and 6. The man ascribes his mistake to being busy with the telephone; but it is suggested that he was talking to a brakesman who was waiting in his box. Anyway, he might have discovered his error had he obeyed instructions and looked to see if No. 7 signal had responded to its lever when he imagined that he pulled it over.

On those railways where the out-door signals are interlocked with the block instruments—"lock-and-block"—the starting signal could not be lowered until the train had been accepted by Ebbw Junction. Major Pringle, in his report, recommends the electrical or mechanical control from Ebbw Junction box of Park Junction starting signal, which will prevent a similar accident in future.

The third case was on September 30th, near Sunnyside Station, Coatbridge, on the North British Railway, when an express special train ran into a light engine. Forty-four passengers received injuries, of whom one has since died.

The diagram in Fig. 3 will help the circumstances of the collision to be understood. The day in question was the last of the Glasgow autumn holidays, and the traffic was very heavy. About 9 p.m. there were three special trains passing through Greenside Junction on their way from Edinburgh to Glasgow. At 8.35 a light engine stood at the connection from Kipps engine shed waiting to proceed along the down main line, but the signalman at Sunnyside Junction—the box in advance—would not accept it. After the second special had passed, the man at Greenside accepted the third special from Airdie South box, but as the Sunnyside man said he would take the light engine in "half-a-minute" he set the road and let out the light engine, which proceeded towards the Greenside starting signal. In thus breaking the block regulations by making a shunting movement after having accepted a train, the signalman at Greenside made the first contribution to the accident. He, however, did this with a view to assisting the operation of the heavy traffic.

The down main home signal at Greenside, and consequently the down distant, were necessarily at danger, and of this there is no doubt, although the driver of the third special said that the distant was "off." There is no need to give here the proofs that he was wrong. Having received "line clear" for the third special, the signalman at Airdie South lowered his signals and the train passed them. This possibly misled the driver. The distant was at danger, also the home, but the train passed the latter signal at a speed estimated by one witness at 50, or possibly 60 miles an hour, and by a locomotive foreman and a driver at 40 to 45 miles per hour. The starting signal had meanwhile been lowered for the light engine, and had been put to danger again, and was "on" when the special passed it; but the latter caught up the light engine with the results already stated.

The driver of the special pleaded in excuse—first, that the distant was "off;" and, secondly, that his brakes failed. That he was incorrect as to the former there is no doubt, and there is no evidence to support him in the latter. The

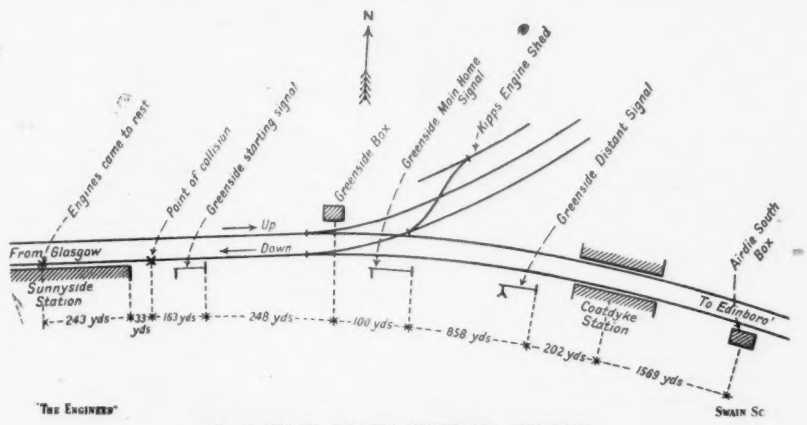


Fig. 3—SCENE OF THE SUNNYSIDE ACCIDENT

train was fitted with the Westinghouse brake. It was drawn by a four-wheels coupled passenger engine with leading bogie and a six-wheel tender, engine and tender weighing 52 tons 14 cwt. There were eleven vehicles—eight with six wheels and three with four wheels, and 44 wheels out of 60 fitted with double-brake blocks. The total weight of the coaches, unloaded, was 213 tons 2 cwt. From a report made by the company's brake inspector it was found on the day after the collision that a reduction of 10lb. from the train pipe set the brake blocks for ten minutes on nine of the vehicles. Upon the tenth the blocks were set, but eased off very quickly owing to an escape of air from one of the piston heads. The blocks were not set at all upon the eleventh vehicle, also owing to leakage. On October 9th the company carried out some experiments with a similar train over the same ground. There are, be it noted, steep continuous falling gradients from Airdie South to Sunnyside Junction. Except for a distance of about 170 yards east and west of Greenside Junction, where the inclination varies from 1 in 160 to 1 in 380, the average gradient is about 1 in 76; the extremes being 1 in 72 and 1 in 90. At the trial the continuous brake was on each occasion applied at the distant for Greenside Junction, and the results were:—(1) With 48 wheels braked out of 64 and the brake applied at the speed of 60 miles an hour, the train was pulled up in 595 yards; (2) with 36 wheels braked, at a speed of 63·4 miles, in 903 yards; (3) with 40 wheels braked at a speed of 56·2 miles, in 878 yards. As there is a distance of 958 yards from the distant signal to the signal-box, there is no question but that the man should have been able to pull up. That he was, to use Major Pringle's words, driving rashly and without due consideration to safety, is proved by the fact that he had run 512 yards past the home signal before the special came into collision with the light engine, and then both engines were locked together and ran for 256 yards, for the greater part of which distance eight pairs of engine and tender wheels were off the road and bumping over the chairs and ballast. Further, there is a speed limit of 10 miles an hour through Sunnyside Station.

It has been said that the light engine stood at the starting signal, which was subsequently lowered. It is therefore possible that owing to the curve of the line the driver of the special sighted the starting signal "off" and overlooked the home signal at danger. The man, too, received no help from his fireman or guard. The former had not been over the line after dark before, and the guard had only once before been in charge of a passenger train on that line—he was a goods guard. Both men said they knew there was a speed restriction, but what the limit was they were unaware. Both were otherwise engaged when passing Greenside and did not see the distant. This does not relieve the driver of any of the seriousness of his offence, and it must be very annoying to the North British Company that twice within twelve months—at Elliot Junction and in this case—their drivers have had to answer to a charge of criminal neglect. On this occasion—thanks to the Scotch law—the driver escaped any penalty, as the jury returned a verdict of "Not proven."

DOCKYARD NOTES.

THE feature of the recent North Sea manœuvres appears to have been the splendid steaming of the King Edward and Vengeance. The Channel Fleet is made up of the King Edward class, two Swiftsures, and two Canopus class, with nominal speeds respectively of 19 knots, 20 knots, and 18·25 knots. In the chase, which was a long stern one, none of these maxima were, of course, made, and all but five ships came a long way behind their trial results, as was, of course, to be expected after long knocking about at sea.

THE chase was headed by the King Edward, with the Vengeance just astern, close to her being the Swiftsure and Triumph. After an interval came the Ocean, then after another interval the rest of the King Edward class, tailing out with the Africa, the laggard of the lot. In most of the Channel Fleet speed runs, something like this order is reached.

WHY the King Edward should be so uniformly a better steamer than her sisters is a matter of interesting speculation, because many of them did a great deal better than she did on their first trials and early steamings. Indeed, about a year ago the King Edward had something of a reputation as a lame duck. Now she is quite the other way.

THE Vengeance has always been a good steamer, and 19 knots has often been got out of her. In the chase she averaged 18 knots; and in relation to legend speed may be regarded as having done better than any other ship. As, however, she has always steamed well, her performance attracted less attention than that of her sister the Ocean. The Canopus class are now getting old and regarded very often as "a bit worn out." They have been tinkered from time to time, but the only one that has had a real refit is the Vengeance. The Ocean has done very poorly in the way of being refitted, so the fine steaming of this old ship is a great credit to all concerned.

THE new Japanese battleship laid down at Yokosuka last May has been named Huki. It is understood that the original decision to give her twelve 12in. guns has been abandoned, and she will mount only ten 12in., together with a greatly increased battery of 6in. and 4·7's—both calibres being apparently decided on for her.

THE 4·7's are, of course, anti-torpedo-boat armament, but the 6in. appear to have been selected on exactly the principle that such guns were selected before the war. Japan's adherence to the 6in. is interesting and remarkable, so much having been written here about its uselessness, as demonstrated at Tsushima. Apparently the Japanese were too busy sinking the Russians to observe the demonstration, or else they saw more than some of the experts who were not there.

IT will be observed that Japan has not lagged behind in adopting the fashionable increase of big guns, it is merely that she has done so without throwing the small gun overboard.

IN a daylight big ship battle the Dreadnought would probably be a Triton among the minnows; but at night, with destroyers about, we fancy we should be happier in the King Edward with a broadside of 6in. to reinforce the 12-pounders.

THE Minotaur class are now beginning to be about. They differ greatly from the Warriors, being less low in the water, and without the "rake" of the earlier cruisers. They are nothing like so smart to look at, as ships. A peculiarity of the Minotaurs is that the funnels are unequally spaced, the fore funnel being placed almost against the foremast, with a quite distinct gap between it and the other three. Also stern walks reappear, and the gun turrets are very "French" in appearance, the small barbettes under them standing up several feet from the deck.

THE AVONSIDE ENGINEERING WORKS

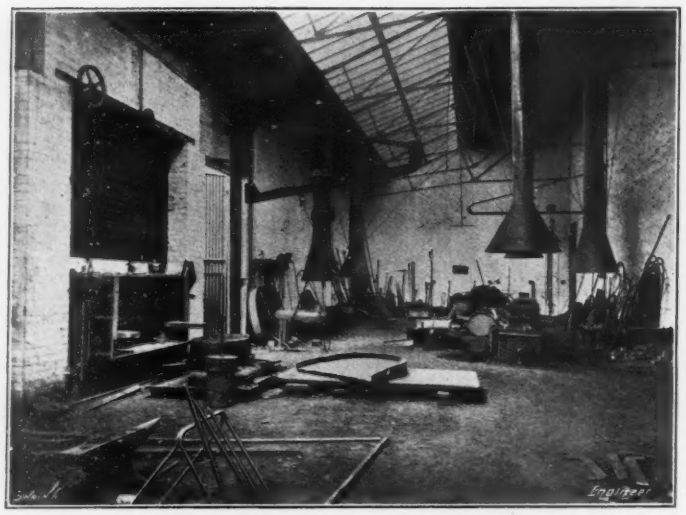


Fig. 1—FLANGING AND ANGLE SMITH'S SHOP

Fig. 2—THE SMITHY

THE AVONSIDE ENGINEERING WORKS.

FOR many years the works of the Avonside Engine Company were situated at St. Philip's, in the heart of the city of Bristol. But owing to the rapid encroachment on the available space, it was decided some three or four years ago to remove the works to another district in Bristol. After giving consideration to various sites, the present position was chosen as being the healthiest, most convenient, and in other respects the most desirable. It is situated at Fishponds, a suburb of Bristol, and is about four miles from the centre of the city. The firm has bought about five acres of land in order to allow for any extensions which may subsequently be made. The works adjoin the railway station, which is on the main line from Birmingham to Bristol, served by the Midland Railway, and special sidings have been constructed for their convenience. The South Wales district is also readily accessible by means of the Great Western system round by the Severn Tunnel, and this company also serves the Hereford and Shrewsbury districts. It will therefore be seen that so far as railway communication is concerned, the new works are well situated. We were informed, however, that it was found to be expensive to carry raw material for the works from the Midlands by rail, and that in the case of boiler plates, the majority used were brought by boat from Scotland, because they could be obtained for about £1 per ton cheaper delivered at the works, and were equal to, if not better than, those obtained from the Midlands. Most of the other materials were bought in England. Bristol's cheap supply of electricity does not yet extend to the outlying district of Fishponds or this source of power would have been adopted to run the works. As it is, a steam plant is used as being the most serviceable for this class of work.

It is hardly necessary for us to remind our readers that the firm almost solely manufactures locomotives. These engines vary in size from the very small shunting locomotives with cylinders 6in. in diameter up to the large six-coupled bogie engines with cylinders 16in. in diameter and stroke 24in. Two of these latter engines were under construction at the time of our visit. We may add, too, that the small locomotives for the rail-coaches on the Great Northern Railway were made at these works. It is not, however, so generally known that the firm has lately taken to making exhaust gas boilers. These are of very simple construction. They are cylindrical, with an ordinary inlet and outlet, and are fitted throughout with 2in. diameter tubes.

Several views of the works are shown in the accompanying illustrations, which, however, are reproduced from photographs taken some time ago, since when the different shops have had several slight alterations made. The machine shop, fitting shop, and erecting shop are all under one roof, and so far as this arrangement permits the raw material passes from the stores through the machine shop, which occupies one bay; from there to the fitting department, and finally to the erecting shop. The machine shop, of which we give two views, Figs. 3 and 5, on page 626, is 250ft. long by about 60ft. in width. It contains mostly machines of a heavy type, and as there is practically no repetition work, the machines for this class of work are almost entirely absent. The lathes, boring machines, radial drills, and milling machines are arranged in groups, the system being clearly shown in the engraving. The long central row of shafting is driven by a 150 horse-power high-speed vertical engine made by Mather and Platt, of Salford, the steam being generated in a Lancashire boiler of Ruston and Proctor's make. The boiler-house is adjacent to the works, and there is no tall shaft, an induced draught being obtained by means of a belt-driven high-speed fan. Rain water is collected in a large tank, and this, mixed with about an equal quantity of the Corporation's water, is used for the boiler.

To prevent the formation of scale, a boiler composition known as M D is used, and we were told that this material was found to take the scale off the boiler and to prevent any other scale forming. The fuel used is obtained locally. At present experiments are being made to obtain a mixture of the different local coals which will give the best result. With one of these coals it was found that 2 tons 18 cwt. were burned per day, and 25 per cent. ash was obtained. With another coal the consumption dropped to 2 tons 4 cwt. a day, and the ash amounted to 12 per cent. A mixture of the two kinds was then tried, and amount burned showed a further slight decrease, being 2 tons 3 cwt. Returning to the machine shop, it will be noticed that small travelling cranes run down the side of the bay for handling the material on the different machines.

Lines are laid down in the shop for the use of small trolleys, which carry the work from one place to another. One of these little cars is shown on the left of the engraving, Fig. 3. The whole of the works are very well lighted and ventilated, and at night time incandescent gas is used as the illuminating medium. The wooden blocks which have been laid down in the fitting, machine, and erecting shops make an excellent and serviceable flooring. An illustration of the erecting shop is shown in the engraving—Fig. 4, page 626—which also shows some of the types of the smaller engines constructed by the firm. This shop is 250ft. in length by about 60ft. in width. Two sets of lines of standard gauge are laid, which allow ordinary railway trucks to enter the shop. There are two overhead cranes in use here; the large one serving the whole shop is capable of lifting a load of 12 tons. It is rope-driven. Most of the riveting work is done by hydraulic power, manual labour only being used in places where machinery would be impossible. The small crane is mostly used for this work, and is shown at the far end of the shop. Here there is also some interesting special machinery for putting the iron tires on the rims of wheels, and also special hydraulic machinery for forcing the wheels on to the crank shafts. It is gratifying to note that in nearly all cases the machinery was supplied by English manufacturers. Only one or two American machines are in use, and there were one or two rather original machines made by the firm some years ago, which were, we were informed, giving excellent results.

Fig. 3—THE MACHINE SHOP

The smithy adjoins the erecting shop, and two views of it are given in Figs. 1 and 2. The whole shop is shown in Fig. 2. Only the smaller class of smiths' work is carried out in the works, the large forgings being obtained from outside firms. A large Roots blower—driven from the main shafting—sufficient for supplying twenty fires, is in use. In the centre of the shop there is a Pilkington's hammer of sufficient power to deal with the work which is handled in the smithy. The lower half of the shop is shown in Fig. 1, and all the flanging and angle smiths' work is done here. Small cranes are erected at different parts of the shop for the convenience of handling the materials. During our visit we saw several good examples of flanging which had just been completed. No castings are made at the Avonside works, but we understand that the firm makes its own castings at a foundry in close proximity to these works. Next to the smithy comes the paint shop, and above this the patternmakers' shop. The former is also the packing shop, and two sets of lines are brought in from the adjacent sidings, so that when the engines have been painted they can be packed up and loaded into the trucks with the least inconvenience possible. This shop is heated by a hot-water apparatus. The pattern shop is approached by an outside staircase. It is a large well-lighted room, a considerable portion of which is taken up by the firm's standard patterns. The drawing-office and general offices also adjoin the works, the manager's office being so arranged that he can see the progress of the work from a window overlooking the main shop, and also the main yard and railway outside the works.

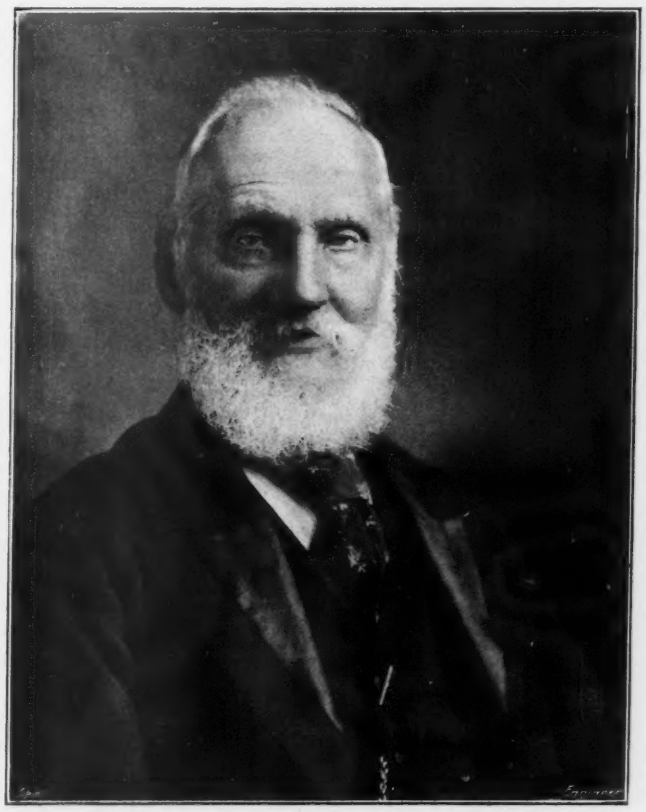
No particular system of payment of wages is adopted by the firm. We were told that it would be practically impossible to work either premium or piecework systems, because there is not sufficient repetition work to be done, and the sizes of the engines being made are so constantly changing. Day work is practically the only method now tried, but knocking down stays and finishing them off is done by piecework.

OBITUARY.

LORD KELVIN.

By the death of Lord Kelvin, which took place at his Ayrshire home, Netherhall, Largs, on Tuesday night, the world has lost one of the greatest scientist who have ever lived, and all civilised nations will join with the country of his birth in mourning for him. The world has produced but few men who can compare with him in genius or ability, and it can ill afford to lose him.

In setting out to review the life history of such a man as the late Lord Kelvin we are at once met with the impossibility of compressing into one short article that which would, to do it properly, require many whole volumes of large size. His intellect was so vast, his knowledge so far-reaching, his skill so versatile, and his attainments so colossal, that there is tremendous difficulty in putting into small compass a record of a life full of works, of inventions, and of discoveries. In a period which has, without doubt, witnessed the greatest development—intellectual, scientific, and industrial—which the world has ever known, Lord Kelvin stands out among his fellows as a man peculiar by reason of his unsurpassed genius. It is not pride of race alone which prompts such a statement as this. Unless we are very greatly mistaken, the scientific journals of every civilised race and tongue will tell the same story. It has frequently been said that he was almost a man apart; that he combined in his own person ability sufficient for at least three distinguished careers; and that that which gave still further nobility to his character was the modesty which did not permit him to see how great he really was. It cannot be said of him that his own generation has failed to acknowledge his achievements, but we venture to predict that, highly as we have held him during his lifetime, the after ages will appreciate him more highly still. The greatness of his work has not even yet been fully realised, yet it cannot be said that he has been without honour, for few have held the number of distinctions, both academical and social, from home and abroad, that he has.



LORD KELVIN

William Thomson was the son of Dr. James Thomson, and was born in Belfast in June, 1824. The father himself was a man of note, who, by assiduous studies and hard work, attained a position of considerable distinction. Son of a small farmer, he chose for himself the profession of schoolmaster, and for some time taught in a school at Ballinahinch, in County Down. He was also a teacher of mathematics at the Royal Academical Institute at Belfast. In 1832, that is to say, when his son William was about eight years old, he was created Professor of Mathematics at Glasgow University, where parts of his studies had been carried out, and he and his family removed there. He himself undertook the first education of his sons, and how well this must have been done is evidenced by the fact that in 1834, when just over ten years old, young William matriculated as a student of the College. Here his progress was rapid, and he won many prizes, including the University prize for an essay on the "Figure of the Earth," which he obtained in 1838, being then only fourteen. At an age which now-a-days would be considered very much too young, namely, fifteen, he went up to Cambridge, being entered at St. Peter's College. He did not take his degree until 1845, when at the age of twenty-one, but when he did take it he was placed Second Wrangler. There is some report that had he had more facility in writing he might have been Senior, but we do not know how much, if any, truth there is in this. However, if not Senior he was Smith's Prizeman, which is by many considered the more noteworthy achievement. We are, unfortunately, not in possession of much detail as to his college life, but what is known is that he was by no means wholly a bookworm. He enjoyed himself vastly there, rowing in his college boat when it was second on the river in the May races, and winning the Colquhoun Sculls in a skiff, so it is said, of his own design. He was also made President of the Cambridge Musical Society, music being one of his great delights.

Shortly after taking his degree he was made a Fellow of his college. Later on, on the occasion of his marriage, he, of course, had to resign this post, for at that time Fellows could not marry and still retain their Fellowship. However, the distiction was re-conferred on him in 1872. This will tend to show what was thought of him at the University, but perhaps this is more strongly brought out by what one of his tutors wrote when it was proposed to appoint him Professor of Natural Philosophy at the Glasgow University. He said that young Thomson was considered by those best able to judge as being the foremost man of science among the rising generation.

And so, while still only twenty-two years of age, he was, in 1846, appointed to this professorship, and went back to Glasgow, but in the meanwhile he had most usefully spent some time studying in Paris under Regnault. Before this period he had written and published a number of abstruse papers. One of these was a defence of certain theorems in Fourier's Harmonic Analysis, and another "On the Uniform Motion of Heat in Homogeneous Solid Bodies, and its Connection with the Mathematical Theory of Electricity." In a way, therefore, young Thomson was already famous when he was but twenty-two; indeed, the very fact that he was given the professorship shows that in actual truth he must have been famous. His appointment reflects great credit on the discernment of those responsible for his choice, for at Glasgow he remained, despite the many temptations which must have assailed him to try his fortunes—which, with his ability, were assured beforehand—in the metropolis. There at the University two whole generations of students have passed through his hands, and if we may judge by the reports of all those whom we have met, and who have sat under him, he must have won the love of all who passed through his hands. Whether he loved all of them—for many of them were troublesome and boisterous at times—is quite another matter.

It would be quite impossible to give even an outline of the work he carried out at the University—that is to say, the academical part of it. It would take too long. It was marvellous that he adhered so long to it; but it is to be believed that it actually became part of himself. The drudgery must have been intense; but though there were, as we have intimated above, restless spirits who would seize every opportunity of interrupting at lecture, there were always those who realised some part, at all events, of the greatness of the man they were listening to, and tried to imbibe all the knowledge possible. One of Lord Kelvin's traits, it may be mentioned, was the interest he took in his past pupils. He was always most delighted to hear from or of them, or of any distinction or good fortune which had come to them. Another noticeable thing was that he never sought to take the credit of discoveries made by students while under his charge. It is said that he always most scrupulously attributed the credit for such discoveries to the persons who made them.

Great as was the work which Lord Kelvin carried out at a teacher of students, the world is probably more in his debt in other directions. There has possibly been no other man who has made so many inventions so widely different in their character. One of the foremost of these is that which made long-distance cable telegraphy a commercial possibility, namely, the syphon recorder. He became interested in cable work almost, if not quite, from its very commencement, and made a deep investigation into the question of retardation of signals, and the effects of capacity and induction. As a result, he was able by mathematical methods to design cables most suited to their special work, but even when these were constructed it was impossible to use long cables with commercial efficiency. It is characteristic of the man that, having realised a difficulty, he set himself to overcome it. The difficulty in this case—to leave out all technical description—was that the signals sent from one end of a cable, if despatched too fast, got mixed up with those which had gone before them, so that it was impracticable to send more than a few signals a minute, sometimes not even that. His first attempt at improvement was the mirror galvanometer. This delicate apparatus consisted of a minute circular mirror, with small steel magnets fixed to its back, suspended by a silk fibre inside a coil of wire. The magnets—and hence the mirror—were deflected either to one side or the other, according as the current sent was in one direction or the other. A beam of light was projected on to the mirror, and the signals sent might be read by watching the moments of the reflected spot of light.

This apparatus, beautiful in action as it was, had this defect, that no record was left. The whole system depended on the fact that the operator must keep his eye resolutely fixed upon the spot of light. This invention was patented in 1858. It was nine years later that the greater discovery of the syphon recorder was achieved. Several other instruments in connection with telegraphy had been patented in the meanwhile in conjunction with Varley and Fleeming Jenkin.

Practically speaking, the syphon recorder is now universally used with all long-distance cables. Like many other really great inventions, it is wonderfully simple. It consists of a small rectangular coil suspended between the poles of a magnet. At first an electro-magnet was used, but now-a-days permanent magnets are employed. The current from the cable is led through this coil, and it accordingly moves round its axis in the magnetic field either one way or the other. Moving with it is a small glass syphon, one end of which dips into an ink reservoir and the other end nearly touches a moving strip of paper. By one of several means, however, the ink is made to issue from the syphon on to the paper, and hence, as the coil, and with it the syphon, moves under the action of the currents from the cable, a continuous record is left on the paper in a sinuous line made by the ink. Not only did this invention produce a record of the messages, but it enabled far greater speeds to be obtained, and had this been Lord Kelvin's only discovery, he would still have been a very famous man.

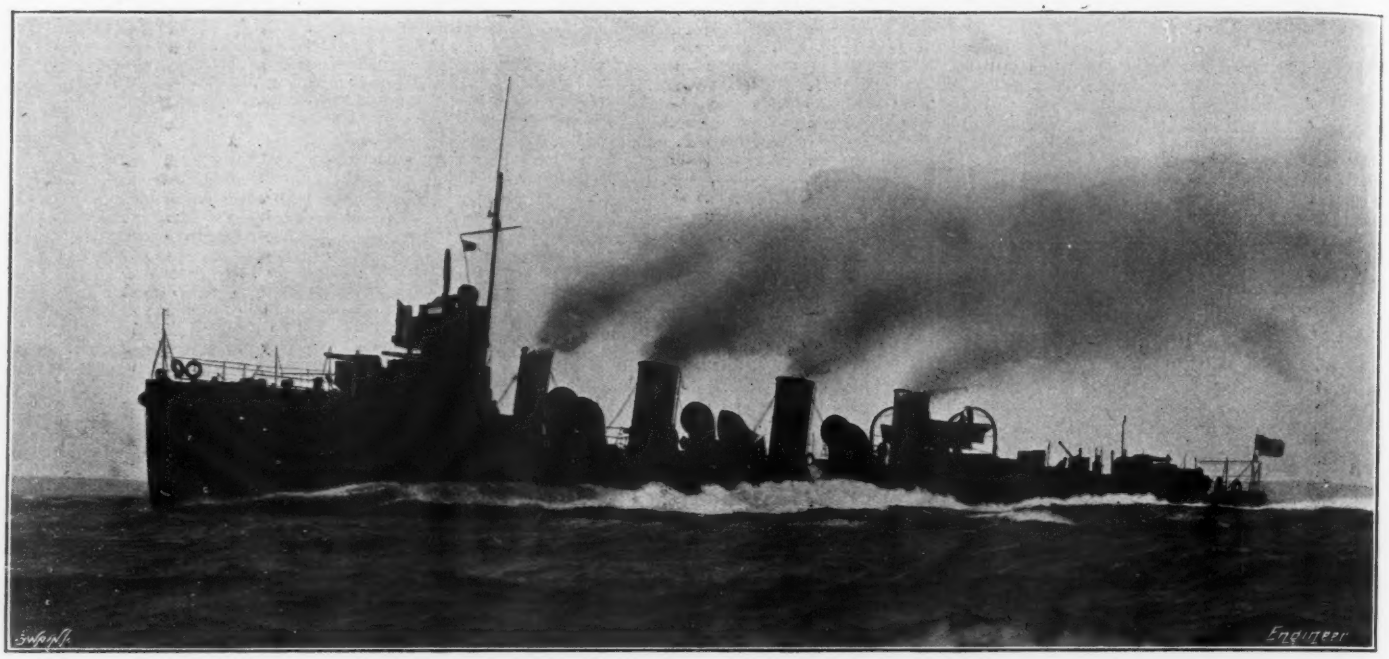
By describing the mirror galvanometer and the syphon recorder, however, we are going somewhat ahead of time. There has still to be told the early history of cables, and of the part Professor William Thomson—as he then was—took in it. In 1856 the late Mr. Cyrus Field succeeded in raising sufficient capital for the construction and laying of a submarine cable between Ireland and Newfoundland. There had been shorter cables before this, as for example, those between Dover and Calais, Harwich and the Hague, and Holyhead and Howth, besides a good many in the Mediterranean, but nothing approaching in length to the first Atlantic cable had up to that time been attempted. At that time Dr. O. W. Whitehouse was the electrician to the Atlantic Telegraph Company. He took exception to some of the statements made regarding cables by Professor Thomson, who promptly replied, and in such a manner that the Telegraph Company saw that he was right, and perceiving that he knew what he was talking about, engaged him to assist it in its undertaking. It was probably owing to this act that the cable was laid when it was, and that the project was not put off indefinitely or actually abandoned, for misfortune seemed to dog its progress resolutely.

The cable was made in two sections—one by R. S. Newall and Co., of Liverpool, the other by Glass, Elliott and Co., of Greenwich. Two men-of-war—the Agamemnon, belonging to this country, and the Niagara, to the United States—each took one of the portions on board, and went to rendezvous in the Bay of Valentia. Professor Thomson and Dr. Whitehouse were in charge of the cable and machinery on the Agamemnon, and Professor Morse, Mr. Charles Bright, and Mr. De Sauty of those on the Niagara. The shore end was landed on August 5th, 1857, and the laying operation commenced by the Niagara. The cable broke, however, and no effort was made to fish up the broken end, and the vessels returned. In the following year another start was made, with more cable and better gear. Professor Thomson was in charge. He was on the Agamemnon, and had with him one of his reflecting galvanometers. It was arranged to start laying from the centre of the Atlantic, the British boat laying cable eastwards and the American boat westwards.

Bad luck was again experienced. The cable broke time after time, and at length both vessels returned to Ireland. However, a fresh start was made, and finally, one end was landed in Trinity Bay, Newfoundland, and the other in Valentia Bay in Ireland. The active life of this unfortunate cable was short. We believe that messages to the number of about 400 were actually sent

HIS MAJESTY'S TORPEDO BOAT DESTROYER TARTAR

JOHN I. THORNYCROFT AND CO., LIMITED, SOUTHAMPTON, BUILDERS



through it, and that it was in operation for some fourteen days. Then it refused to transmit any more signals. We believe that over 300 cells were connected to it when it failed. The labours of Professor Thomson during all these arduous times may be imagined, and it is said that he refused to accept any remuneration for his services.

Such failures might well have daunted the capitalists; and, indeed, for some years nothing more was done. In 1865, however, the Great Eastern, with Professor Thomson, Mr. Varley, Mr. Samuel Canning, and Mr. De Sauty on board, started laying another cable. A thousand miles had been laid when the cable broke and could not be recovered. The huge steamship returned to England, and nothing more was done till the following July. Then again she started, and again Professor Thomson was on board. This time success was achieved, and America was linked up with the Mother Country. Moreover, the cable which had broken during her first attempt was grappled, hauled on board, spliced, and the remainder successfully laid.

It is hardly too much to say that the laying of these cables was due in the main to the efforts of Professor Thomson, and on his return in 1866 he was, with others, knighted by the Lord-Lieutenant of Ireland. His services were immediately afterwards secured by a number of cable companies, and practically nothing in the way of cables was done without his advice being taken.

Sir William was at this time much given to yachting, most of his long vacations being spent on his yacht, the Lalla Rookh. This love of the sea led to the invention of two pieces of apparatus which are now universally employed. The first of these he brought out in 1872, and it was for the purpose of taking deep sea soundings. In this he employed fine steel pianoforte wire instead of the hemp rope, and the results obtained were most satisfactory. It was used in connection with a special depth recorder. Very many fewer men were required to operate it, and it had the advantage that its sinking weight only weighed some 34 lb., instead of the two or three hundredweight which had up to then been necessary. Moreover, with it soundings up to certain depths could be made while the vessel was proceeding at full speed.

The other nautical invention was the improvement of the mariner's compass. The invention of this came out in a peculiar way. Sir William was asked by the editor of *Good Words* to contribute an article on the compass, and the first portion of it appeared in 1874. The second part did not come out till five years later! The cause of this delay was that in going into the matter Sir William was so much struck with the defects of the existing instruments that he set himself the task of devising one himself, which would not have the defects which he had found in the others. Practically all the world now uses the compass which was devised and patented in 1876, and improved at subsequent dates, and no further description of it is needed than that in place of one large magnet needle, a number—usually eight—were arranged by a particularly clever method of suspension, and a saving of weight of nearly 18 to 1 was obtained. The sensitiveness was greatly increased. The compass is carried in a soft iron screen, and is adjusted by means of permanent magnets.

Sir William Thomson, with the object of working out his many inventions more fully, entered into partnership with Professor Fleeming Jenkin, F.R.S., and Mr. Cromwell F. Varley, the latter of whom is identified with the use of the condenser in cable working. With the assistance of these two gentlemen an automatic signalling key was introduced in 1876.

Among other questions to which Sir William gave his attention was the subject of tides. Owing to his representations to the British Association in 1867, a Committee was formed to promote the collection and collation of tidal observations. In 1881 he read a paper before the Institution of Civil Engineers, entitled "The Tide Gauge, Tidal Harmonic Analyser, and Tide Predicter." The tide gauge was different from other tide gauges then existing in certain dynamical and geometrical details. It was designed for giving in more convenient form results of greater or better assured accuracy, with a smaller float, and finer and smaller, but not less hardy, mechanism. The tidal analyser was intended to perform mechanically much of the calculations which up till then could only be made at great labour. It was an application of an instrument devised by his brother, Professor James Thomson. The tide predicter was to foretell the tides for any port for which the tidal constituents had previously been found by the harmonic analyser from observations made with the tide gauge. It was not intended merely to predict the times and heights of water, but to give the depth of water at any and every instant, showing it by a continuous curve for a year or for any number of years in advance.

Every student of electricity knows of the numerous instruments invented by Lord Kelvin for the measurement of electricity and manufactured by the firm of White, of Glasgow. These instruments have world-wide fame for the excellence of their design and workmanship. To name them all would be impossible, yet mention must be made of some of them. In 1846, just after being appointed to his professorship, Professor Thomson gave "a mechanical representation of electric, magnetic, and galvanic forces." In the early fifties he wrote a paper entitled "Applications of the Principle of Mechanical Effect to the Measurement of Electro-motive Forces, and of Galvanic Resistances in Absolute Units," and was a very active member of a Special Committee appointed by the British Association in 1861 for the consideration of electrical standards. The subject interested him deeply, and to him is due in no small part the fact that we now possess such a perfect system of electrical units and standards. About the year 1855 he produced his absolute electrometer, with which some years later he carried out his well-known experiments regarding the potential necessary to produce sparks in air under varying conditions. About this time he brought out his ring electrometer, which he later on perfected and called the quadrant electrometer, and invented a new astronomical clock. His ampère and watt balances are too well known to be more than mentioned. The same may be said of his ingenious electrostatic voltmeters, as well as of the numerous types of ammeters, voltmeters, and wattmeters, which were designed by him, and constructed by the firm of White. They are in every way examples of instruments correctly designed and perfectly made. As an invention of a quite different kind to the foregoing we should mention the water-cocks and taps which bear his name.

Who can in a few words describe the remaining work of this wonderful and busy life? Even to refer briefly to all the subjects to which Lord Kelvin turned his master mind would need more space than we can give. The earth on which we dwell was always a source of intense interest to him, and by deduction from experiments he carried out at an early period of his career, he propounded the theory that its life at the present time was about 98 millions of years. He at any rate expressed himself as satisfied that it could not be less than 20 millions or older than 400 millions of years. Later on he appeared to find reason for supposing that the 98 millions overstated the case, and that the probable life of the planet was nearer the 20 millions of years. He was of opinion that the interior of the earth was solid and not fluid. He predicted and then proved by experiment the electrical convection of heat. He was almost the grandfather, so to speak, of wireless telegraphy, for he verified the supposition of others that oscillations were set up in the ether by the discharge of a Leyden jar. Herz carried his work several degrees further, and others since have gone further still. Lord Kelvin's researches into the size and constitution of atoms, his theory of the ether, his vortex theory, his development of Carnot's theory, and his dynamical theory of heat are historic. His name will always be associated with his mathematical theories of electricity and magnetism. In short, every branch of physics is the richer by reason of his investigations and discoveries, and a lengthy catalogue would be required to contain all his numerous writings and publications.

Possibly no man had a greater number of distinctions showered upon him. For example, he was four times President of the Royal Society. He was one of the very few to receive the Order of Merit, being one of the first eight to be so honoured. He was P.C.; G.C.V.O.; LL.D.; D.C.L.; these titles being conferred by numerous universities at home and abroad; D.Sc.; M.D.; and D.L. He was member of the Prussian Order pour le Mérite; Grand Officer of the Légion d'Honneur; Commander of the Order of King Leopold of Belgium; of the Order of the First Class of the Sacred Treasure of Japan; Foreign Associate of the French Academy; and Foreign Member of the Berlin Academy of Science. In 1891 he was, with Professor Unwin, Professor E. Mascart, Dr. Coleman Sellers, and Col. Th. Turretini, appointed to the International Commission for determining the method to be adopted in obtaining electrical power from Niagara Falls. He was an honorary member of the Institution of Civil Engineers and of the Institution of Mechanical Engineers. He was consulting engineer to numbers of electrical undertakings. He was several times President of the Institution of Electrical Engineers and of the British Association, being actually in the former office at the time of his death. He was raised to the peerage by Queen Victoria in 1892, assuming the title of Baron Kelvin of Netherhall, Largs. In 1896 he celebrated his jubilee as Professor at Glasgow, and delegates from all over the world came to offer him their congratulations. Three years later he gave up his professorship, though his active business life was by no means ended at this time. He was twice married, and his second wife outlives him.

His was the kindliest of dispositions. He was always ready to lend a helping hand to those in trouble or distress, and, in fact, a life better spent than his cannot be imagined.

THE OFFICIAL TRIALS OF THE TARTAR.

H.M.S. TARTAR, the new 33-knot British destroyer, which had already, in its preliminary trials, broken the world's record for speed by attaining 35·952 knots on an Admiralty course, carried out its final speed trials on Monday, December 16th, in the presence of various Admiralty officials. The vessel maintained the speed of 35·363 knots throughout a continuous run of six hours' duration, thus covering a total distance of nearly 233 miles during this period. On six runs over the measured Admiralty knot during the six hours' run the mean speed proved to be 35·672 knots, and the best speed attained on any one run was 37·037 knots, thus creating still another record.

Built throughout and engined by John I. Thornycroft and Co., Limited, at their works opposite Southampton Docks, the Tartar is one of the first five high-speed ocean-going destroyers now being completed for the Admiralty.

The turbines of the Tartar are of Parsons type, and these, as well as the Thornycroft boilers using oil fuel, were constructed by Messrs. Thornycroft. The whole of the machinery worked excellently throughout the trials, and the boilers provided an ample head of steam at all times. The oil fuel consumed was, we are informed, considerably within the guaranteed limit.

RAILWAY MATTERS.

THE Great Western Company recently commenced operations for widening Newport tunnel, so as to admit of the laying of two more sets of lines to take the Western Valley mineral traffic.

THE Brussels *Petit Bleu* states that an agreement has been reached between Great Britain and the Congo Free State for the construction of a railway line connecting the Lado Enclave and the Congo frontier.

STEEL cross-sleepers of trough section placed 6ft. on centres have been used on about 75 per cent. of the city lines of the Montreal Street Railway. Under each line of rails there is a concrete beam, while between the beams there is the usual concrete foundation for the pavement.

THE Board of Trade have recently confirmed the undermentioned Order, made by the Light Railway Commissioners:—Maidstone Corporation Light Railways (Extensions No. 2) Order, 1907, authorising the construction of additional light railways in the Borough of Maidstone.

IN view of the early development of the Rhymney Iron Company's new pits at Darran, the Rhymney Railway Company is doubling its branch line from Bargoed to Dari Junction. A new station with goods warehouse and improved siding accommodation at Darran are included in the contract.

ON Monday last Mr. T. R. Whitehead, manager to the Coventry Electric Tramways, Limited, stated, in reference to the cause of the overturning of one of the company's cars on Sunday, that after examination at the depôt the brakes appeared to be all right and in perfect working order. The rails were, however, in a greasy condition, and his opinion was that the car skidded.

"THE ability of the electric lines," says the *Railway Age* of Chicago, "to absorb the passenger traffic where there is a relatively short haul has been demonstrated, and, with the same tendency apparent with respect to freight business, it is to be expected that the steam railroads will ultimately secure control of inter-urban electric lines to serve as branch lines and feeders."

OVER 500 workmen were engaged in the reconstruction of the Pontypridd (Taff Vale Railway) Station last week. The work is estimated to cost £200,000, and the station, which is one of the busiest in Wales, will also be one of the most commodious. The new island platform will be 510 yards long and 22 yards wide. In raising the level of the main down line to Cardiff, no less than 6000 tons of ballast were used.

WE hear that about a dozen of the most modern electric tramcars are to be added to the equipment of the Leeds city tramways. The additions will bring up the total number to about 280. About a million and a-half passenger fares are already taken each week on the tramways. Extensions in various directions are in progress. Special attention is to be paid to the brakes, as there are some very steep gradients on this system.

IT is reported that, after an interesting discussion, the Swiss Council of States on December 10th agreed to the scheme put forward by the management of the Federal Railways and endorsed by the Federal Council for the construction of a second tunnel through the Simplon, and voted the sum asked for in connection with the scheme in the Federal Railway estimates. The question, however, still has to come before the National Council.

THE Prussian State Railways have comparatively recently had a limited number of goods wagons equipped with continuous brakes. It is now decided to increase the number, and during the current year 320 wagons are to be equipped, and 140 next year, making a total of 600, which will for the most part be run in certain fast freight trains making regular trips. Hitherto, on certain lines, no more than sixty axles were permitted in such trains, but hereafter there may be eighty.

THE *Bollettino delle Finanze* of November 17th announces that Signor Enrico Ferruzzi has made an application for the construction of a railway from Sora to join the Rome-Naples line at Cassino, and also a branch communicating with Formia. The *Bollettino* of November 21st announces that the Consiglio Superiore dei Lavori Pubblici has approved the project for the construction of a new railway of narrow gauge, which is to join the existing line from Schio Torre to Recoaro.

THE Richmond Town Council have passed a resolution to request the London United Tramways Company to promote a Bill for the construction of a tramway across Kew Bridge. The resolution is the outcome of several years' negotiations, and the company has agreed to waive the further consideration of the overhead trolley wire for the Kew-road line and to lay down a system of surface traction instead. The proposed line will bring Richmond into communication with the company's main system from Shepherd's Bush and Hammersmith to Hampton Court and Hounslow.

THE Vaccaro Brothers Railroad, now being built along the north coast of Honduras from Laceiba west to Porvenir, Salado, San Francisco and Santiago, 35 miles, is expected to be in operation some time in the spring of 1908. Three spurs from the main line at different points will penetrate five to eight miles inland, tapping farming country, while projected extensions of these spurs will eventually reach hard-wood timber some 20 miles from the coast. The completion of this first section of the 150 miles of projected road is expected to divert the greater part of the marine commerce from the towns mentioned and centralise it in Laceiba.

THE Grand Trunk Railway has been beaten in the fight it has made against the order of the Railway Commission to run third-class carriages at the rate of one penny a mile between Montreal and Toronto. The company appealed to the Supreme Court against this order, but the latter Court has decided that the order must stand. This order is in accordance with the Grand Trunk's charter, but the company stopped running cars at this rate on the ground that they were unremunerative. Now that the order is to be enforced it is believed that it will lead to penny fares being established everywhere in Eastern Canada, though not on express trains.

REPORTS from Buenos Ayres state that the contract for the sale of the Andino Railway will be signed *ad referendum* by the Minister of Public Works, subject to final approval by Congress. The sale price is £4,465,600. This sum will be applied exclusively to construction of extensions of narrow gauge lines owned by the Government, and to complete that system, as the Andino line, being of broad gauge, outlet and junction with that line is considered impracticable. The proceeds of this sale, not being considered as revenue, will be deposited in a special account for the above purpose, and will not be appropriated to cover ordinary expenditure nor for the purchase of armaments.

THE Board of Trade report upon the fatal collision which occurred on September 30th, between a special passenger train and a light engine near Sunnyside Station, Coatbridge, on the North British Railway, was issued last Monday. Major Pringle, summarising his conclusions, says: "I have carefully weighed all the evidence available in this case, and have come to the conclusion that the down distant signal for Greenside Junction was at danger when the excursion train passed it, and that if driver Ekevall (of passenger train) had duly observed the warning position of this signal, and had acted upon it, there was ample brake power upon the train for him to have avoided the collision."

NOTES AND MEMORANDA.

ROSCOELITE, a vanadium mica, occurs in South-Western Colorado, where it was mined and reduced during 1906. The mineral contains about 2 per cent. vanadium.

ACCORDING to Le Chatelier, the presence of nitrogen to the extent of 0·02 to 0·045 per cent. in steel is enough to cause the metal to break at greatly reduced stresses and to destroy practically all ductility.

THE output of coal in Natal in October was 148,516 tons, as compared with 116,964 tons in October, 1906. Of this quantity, 109,440 tons were shipped, 71,206 tons as bunkers, and the remainder as cargo.

DESCRIBING the derrick crane at the corner of Piccadilly and St. James s-street as a public danger, Mr. Denman made an order for its removal in twenty-four hours at Marlborough-street Police-court last Wednesday.

ACCORDING to the *Engineering and Mining Journal*, most of the platinum exports of Colombia are from Cartagena and Barranquilla, though exports through the ports of Buenaventura are said to be increasing in quantity.

ACCORDING to a contemporary, a preparation particularly suitable for filling pneumatic tires so as to make them puncture-proof, or for moulding, is obtained by heating together 1 lb. of glue, 1 lb. of molasses, 4 fluid ounces of glycerine, and ¼ teaspoonful of tar.

THE quantity of mercury smelted in Russia for the first ten months of this year is reported by the *Torg. Prom. Gazeta* at 6875 poods, against 10,949 poods in the corresponding period of last year. The same journal makes the announcement that in the Verchoturek district, on the Vagran Government estate, mercury deposits have been discovered.

THE output of coal in Peru in 1906 was 79,900 tons, as against 75,300 tons in the previous year. The output of oil increased from 50,000 tons to 71,000 tons. The greater bulk of the coal was raised in the Cerro de Pasco district. The copper output showed an increase over the previous year, and amounted to 13,500 tons, this figure including ingots, mattes, and mineral.

A NOTE in the *Iron Age* states that the National Foundry Company, Erie, Penn., is now pouring from 200 to 270 moulds per heat in its steel foundry. It recently broke the record by pouring 275 moulds, it it said, from an 18-ton heat in one hour and thirty-five minutes. Although some of them weighed but 2 lb. apiece, the castings would average about 60 lb. each, there being 580 pieces in the heat.

IT is reported that in spite of a strong wind the dirigible balloon Ville de Paris manœuvred last Tuesday morning over Paris, continuing a series of tests which are being carried out on her before proceeding to Verdum. M. Santos Dumont experimented on Wednesday morning with the motor of his new aëroplane, when the belt driving the propeller shaft broke and slightly damaged the apparatus.

THE total production of limestone and dolomite for flux in the United States in 1906 is reported by the United States Geological Survey at 16,077,202 long tons—an increase of 689,311 tons over 1905. The total value in 1907 was £1,522,538, the average value at quarry being 1s. 11d. per long ton. The larger outputs were 6,396.765 tons in Pennsylvania, 3,096,346 in Ohio, and 1,019,931 in West Virginia. Dolomite is used chiefly in Alabama.

A LONG reinforced concrete bridge has recently been completed to carry the trucks of the Lima and Toledo Traction Company across the Maumee River at Waterville, O. The bridge is 30ft. wide and 1220ft. long, and consists of twelve spans increasing in length from 15ft. at each side to 90ft. in the centre, with a crown thickness of 2ft. and a haunch thickness of 4ft. 6in. The amount of material used in its construction includes 10,000 cubic yards of concrete, 240 tons of reinforcing steel and 60,000 cubic yards of earth fill.

THE water-power electric plant belonging to the sanitary district of Chicago began operations on November 26th. The plant utilises the water-power of the Chicago drainage canal, and has cost about £800,000 to construct. It is estimated that when a flow of 10,000 cubic per second, or 600,000 cubic feet per minute is reached, the annual revenue from the sale of current will reach £145,200. Contracts for the supply of current have been made with the city of Chicago, the West Park Board and towns outside the Chicago city limits.

THE author of a paper read in America points out the disadvantages of single-phase generating plant, which has the sole merit of simplicity, and proceeds to consider various methods of distributing single-phase power derived from a three-phase source. Motor generator sub-stations are satisfactory but costly. Single-phase distribution from the three phases leads to serious unbalancing with a railway load, and other drawbacks. Two-phase distribution from three-phase supply, and two-phase generation, are alike subject to unbalancing.

THE Connecticut River bridge at Hartford, one of the largest and most imposing series of granite masonry arches in America, was formally opened for traffic on November 29th. This structure, 1192ft. long, and consisting of nine arch spans, was built at a cost of about £340,000 to replace an old wooden bridge destroyed by fire in 1895. Especial care has been taken in the arrangement of the approaches, particularly on the Hartford side where the city has constructed a new park costing about £160,000 for land condemnation and reclamation.

DURING a recent thunderstorm in America lightning twice struck the Singer Building within an interval of five minutes. The first flash was in the form of a ball of fire, which struck the dome and darted down the southern side of the structure for 80ft. or more, in the form of a streak of fire, disappearing long before it reached the ground. The scaffolding was evidently ignited by the charge, for a bright light glowed there for some minutes before it was extinguished by the falling rain. The second discharge struck the flagpole, and is supposed to have split it. It appeared as a flash that lighted up the flagpole as it hit the ball on the top.

ACCORDING to the *Iron and Coal Trades Review* the United States Steel Corporation, through its subsidiary, the Oliver Iron Mining Company, is opening up what will be the largest mine of the kind in the world. With the aid of steam shovels and standard-gauge dump wagons having a capacity of 7 to 9 tons, something like 20,000,000 cubic yards of dirt will be removed from the surface of the Canisteo iron ore deposit. This open pit, to be clover leaf in shape, covers 200 acres, and when the necessary development work has been done, will be from 150ft. to 200ft. deep. One of the principal features of this great enterprise will be the washing of the iron ores.

WHILE measuring the resistance of a sample of antimonite in different directions, it was noticed that light caused a great alteration in the amount of current passing. In some cases the conductivity increased by over 200 per cent. by exposing the substance to the light from an incandescent lamp. If a thick sheet of colourless plate-glass is interposed between the lamp and the substance the conductivity is increased still further. Hence rise of temperature has an influence directly opposed to light radiations. If glass plates of different colours are used it is found that the increase of conductivity with red light is large, for yellow larger, for green very small, for violet light again large, and there is again a minimum in the ultra-violet.

MISCELLANEA.

IN Southern India the Government are offering the fullest encouragement to planters to undertake the cultivation of camphor in the Nilgiris.

A REPORT from Birmingham, Alabama, states that an explosion of gas occurred last Monday in the Tuscaloosa County Mine. Out of seventy-five men who were working in the shaft only eight have escaped, and they are badly injured.

THE Harrogate Town Council have received sanction from the Local Government Board to the borrowing of a further sum of £15,000 towards defraying excess expenditure incurred in the execution of the schemes of sewerage and sewage disposal.

THE Newlyn Treasury has agreed to make a grant of upwards of £10,000 towards the cost of harbour improvements at Newlyn, which are estimated to cost over £30,000, and will, it is hoped, make the Cornish village one of the most important fishery centres in the kingdom.

THE Keighley Town Council recently approved the parliamentary Bill to be promoted by the Council next session. It seeks powers in connection with the construction of reservoirs, the running of motor omnibuses, the extension of electricity and gas undertakings, and other matters.

THE Sligo Harbour Commissioners have been officially informed that the Treasury have granted the sum of £20,000 towards carrying out improvements at that harbour, for which designs and estimates have been prepared by their engineer, Joseph Mallagh, A.M. Inst. C.E.

THE platinum industry in British Columbia is reported to be making good progress. It is stated that a French company recently acquired considerable land in the platinum district, and is having this territory carefully examined by experts. Other companies have also secured ground, which is to be exploited.

THE movement to develop a naval base on the Pacific coast as a consequence of the movement of the battleship fleet has taken shape in the form of proposed legislation introduced by Representative Hayes, of California, to provide for a Commission to select a site for a naval station on San Francisco Bay and for a dry dock and repair station at San Diego.

A REPORT sent to Berlin from Friedrichshaven states that damage to the extent of £2500 was caused by the storm to the floating balloon shed on Lake Constance, in which Count Zeppelin's airship is housed. The pontoons supporting the shed filled with water, and the shed was driven ashore, where it grounded. The bows of the airship were seriously damaged.

THE Meteorological Office are at present endeavouring to make arrangements for the taking of daily sunshine and weather observations at Hindhead, Surrey, which is 897ft. above sea level, and the highest inhabited district in the South of England. Harrogate, in Yorkshire, 700ft. above sea level, is at present the only inland elevated spot where daily sunshine records are published.

A NOTABLE achievement in warship wireless telegraphy was made by the staff of the Cornwallis on the way home from Gibraltar, by keeping in touch with that port during the entire passage, extending over 900 miles, and also in communicating with the Scilly Island station when almost 200 miles distant. The instruments in the Cornwallis are of the improved service type, and the results are said to have been highly satisfactory.

A SPECIAL meeting of the Lincoln City Council was held last Monday, when it was decided to seal a petition, required by the Standing Orders of Parliament, to be deposited in the Private Bill-office of the House of Commons on Tuesday, for a Bill to confer further powers upon the Lincoln Corporation with respect to their water undertaking; and to authorise the Corporation to construct additional waterworks, and to extend their limits for the supply of water.

WE hear that from February 1st next the Transvaal Government will pay the Portuguese Government a bounty of 4½d. per ton on the coal shipped at Delagoa Bay. In return, the Portuguese Government will expend immediately a sum of £7000 on coaling facilities at Delagoa Bay on the same scale as those at Durban, and will also demolish the demurrage on trucks awaiting shipment. It is hoped that the Transvaal coal industry will be fostered by this arrangement.

ON Monday last the steam pinnace of the battleship Magnificent was damaged at Sheerness in a collision, during the dense fog in the Medway, and sank. The crew and the blue-jackets on board were rescued. The collision was with the steam pinnace of the cruiser Roxburgh. The Roxburgh boat took off the men from the Magnificent's pinnace before she foundered. The fog was very dense at the time of the accident, and the boats were not visible to each other until too late.

ENGLISH manufacturers and export firms may, says the St. Petersburg correspondent of the *Globe*, be reminded that there is now a splendid opportunity for finding a market for their goods in Poland. Germany's treatment of the Poles has led to the Poles boycotting German goods of all kinds; thus the present moment in Poland is one which ought to be turned to the best account by English firms. It may be pointed out that Warsaw is becoming an important centre of trade with Siberia and the Far East, especially with regard to foreign-made agricultural implements of all kinns.

IT is reported that an extraordinary accident occurred near the Maplin Sands last Tuesday. A new high-speed destroyer which was undergoing full speed steam trials collided with the steamer Annandale, which was run ashore last week after colliding with the steamer Kingscote. The Annandale had then a large hole knocked in her side near the engine-room, and this had since been repaired by the salvage men placing a huge plate over the hole to enable the Annandale to be refloated and docked. It is reported that the destroyer, as a result of the collision, completely carried away the repairing plate, and herself sustained considerable damage.

WE hear that instructions have been given for the battleship Vengeance, and the cruiser Ariadne, which is temporarily under the orders of the Commander-in-Chief at Portsmouth, to carry out confidential experiments with a system of fire-control, the joint invention of a civilian and a naval engineer. About two years ago the battleship Jupiter was engaged in experiments with this invention for about four months. As the result of the experience then gained improvements were made in the fittings, and subsequently the system was fitted in the Ariadne. It has now been extended to the Vengeance, and the present experiments are to be conducted under the supervision of Admiral of the Fleet Sir A. K. Wilson.

A PROJECT is on foot for the provision of a commercial pier near Langney Point, close to Eastbourne. It is estimated that the cost of this work will be about £60,000. The site of the intended works is about 1½ miles east of the town, and close to the gasworks and the electric power station of the Corporation. The proposed works consist of two arms; the eastern arm, about 1200ft. long, will be the landing stage, and will provide a depth of 30ft. to 35ft. at high-water ordinary spring tides. The western arm, 1000ft. long, will form a wave screen or breakwater for the protection of vessels discharging at the landing stages. In rough weather these vessels will lie to moorings and will be served by long-reach cranes. The deep-water structure will be built exclusively of armoured concrete, portions of the approaches being of timber.

THE AVONSIDE ENGINEERING WORKS

(For description see page 622)

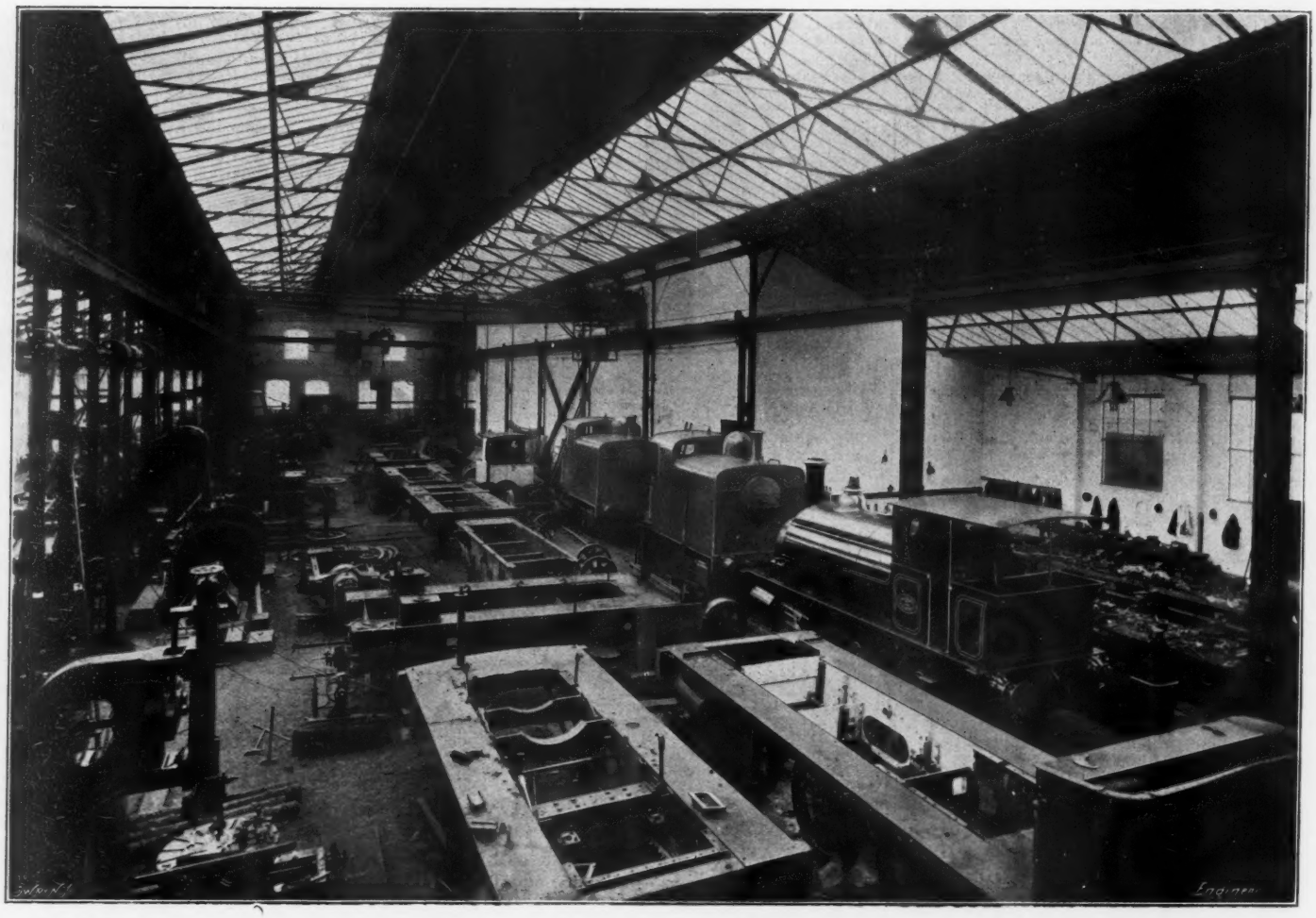


Fig. 4—THE ERECTING SHOP

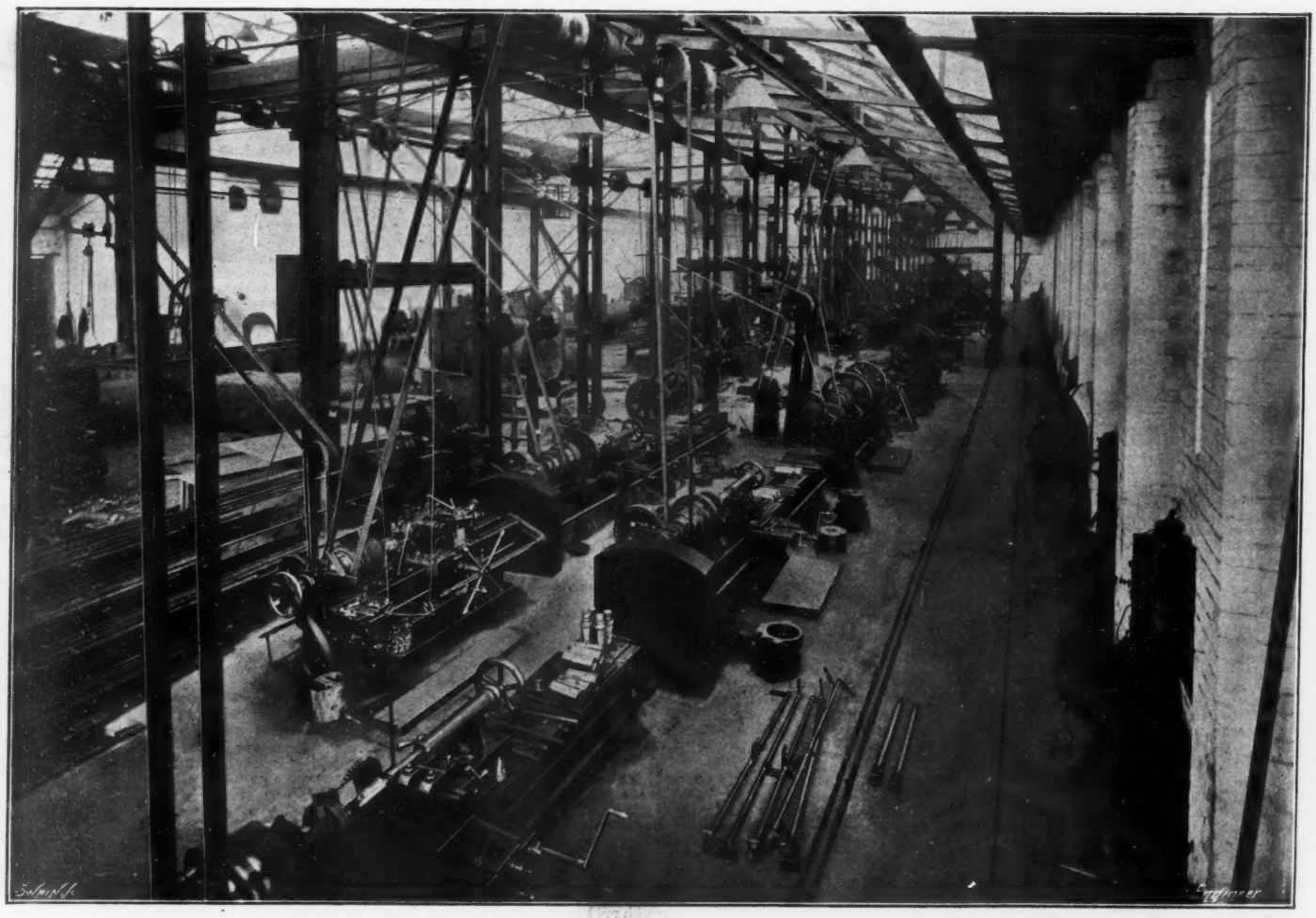


Fig. 5—THE MACHINE SHOP

FOREIGN AGENTS FOR SALE OF THE ENGINEER.

AUSTRIA.—F. A. BROCKHAUS, *Seilergasse 4, Vienna.*
CHINA.—KELLY AND WALSH, LIMITED, *Shanghai and Hong Kong.*
EGYPT.—F. DIEMER, FINCK & BEYLAENDER, *Shepheard's-buildings, Cairo.*
FRANCE.—BOYVEAU & CHEVILLET, *Rue de la Banque, Paris.*
CHAPELOT & CIE., *Rue Dauphine, 30, Paris*
GERMANY.—ASHER AND CO., *5, Unter den Linden, Berlin.*
F. A. BROCKHAUS, *Leipsic;* A. TWEITMEYER, *Leipsic.*
INDIA.—A. J. COMBRIDGE AND CO., *Railway Bookstalls, Bombay.*
ITALY.—LOESCHER AND CO., *307, Corso, Rome;* BOCCA FRERES, *Turin;* ULRICO HOEPLI, *Milan.*
JAPAN.—KELLY AND WALSH, LIMITED, *Yokohama.*
Z. P. MARUYA AND CO., *Tokyo and Yokohama.*
RUSSIA.—C. RICKER, 14, *Nevsky Prospect, St. Petersburg.*
UNITED STATES OF AMERICA.—INTERNATIONAL NEWS CO., *83 and 85, Duane-street, New York;* SUBSCRIPTION NEWS CO., *Chicago.*
S. AFRICA.—WM. DAWSON & SONS, LIMITED, 7, *Sea-st.* (*Box* 489), *Capetown.*
CENTRAL NEWS AGENCY, LIMITED, *Johannesburg, Capetown, Durban, &c., and at all their Bookstalls.*
J. C. JUTA AND CO., *Capetown, Port Elizabeth, Johannesburg, East London, Grahamstown.*
AUSTRALIA.—GORDON AND GOTCH, *Melbourne, Sydney, and Queen-street, Brisbane, &c.*
MELVILLE AND MULLEN, *Melbourne.*
TURNER AND HENDERSON, *Hunt-street, Sydney.*
NEW ZEALAND.—GORDON AND GOTCH, *Cuba-street Extension, Wellington, and Bedford-road, Christchurch.*
UPTON AND CO., *Auckland;* CRAIG, J. W., *Napier.*
CANADA.—MONTREAL NEWS CO., *386 and 388, St. James-street, Montreal*
TORONTO NEWS CO., *42, Yonge-street, Toronto.*
CEYLON.—WIJAYARTNA AND CO., *Colombo.*
JAMAICA.—SOLLES AND COCKING, *Kingston.*
STRAITS SETTLEMENTS.—KELLY AND WALSH, LIMITED, *Singapore.*

Subscriptions received at all the Post-offices on the Continent.

SUBSCRIPTIONS.

THE ENGINEER can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office on the following terms (paid in advance):—

Half-yearly (including double number) .. .. £0 14s. 6d.
Yearly (including two double numbers) .. .. £1 9s. 0d.

CLOTH READING CASES, to hold six issues, 2s. 6d. each, post free 2s. 10d.

If credit occur, an extra charge of two shillings and sixpence per annum will be made.

Foreign Subscriptions will, until further notice, be received at the rates given below. Foreign Subscribers paying in advance at these rates will receive THE ENGINEER weekly and post free. Subscriptions sent by Post-office Order must be made payable to THE ENGINEER, and accompanied by letter of advice to the Publisher.

THIN PAPER COPIES.		THICK PAPER COPIES.	
Half-yearly	£0 18s. 0d.	Half-yearly	£1 0s. 3d.
Yearly	£1 16s. 0d.	Yearly	£2 0s. 6d.

(The difference to cover extra postage.

ADVERTISEMENTS.

☞ The charge for advertisements of four lines and under is three shillings, for every two lines afterwards one shilling and sixpence; odd lines are charged one shilling. The line averages seven words. When an advertisement measures an inch or more, the charge is 10s. per inch. All single advertisements from the country must be accompanied by a Post-office Order in payment. Alternate advertisements will be inserted with all practical regularity, but regularity cannot be guaranteed in any such case. All except weekly advertisements are taken subject to this condition.

Advertisements cannot be inserted unless delivered before Five o'clock on Thursday evening, and in consequence of the necessity for going to press early with a portion of the edition ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

Telegraphic Address, "ENGINEER NEWSPAPER, LONDON." Telephone—No. 13352 Central.

PUBLISHER'S NOTICES.

*** *Next week being Christmas week, Advertisements cannot be inserted unless delivered before Twelve o'clock on Thursday mid-day.*

*** *If any subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the Paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

CONTENTS.

THE ENGINEER, 20th December, 1907. PAGE

THE ROYAL COMMISSION ON COAST EROSION. No. I. 613
STRENGTH OF RINGS. (Illustrated.) 614
GAS POWER PLANT AT AN ENGINEERING WORKS. (Illustrated.) .. 616
THE GREAT NORTHERN AND GREAT CENTRAL AGREEMENT 618
THE GREENWICH BOILER EXPLOSION 620
FATAL RAILWAY COLLISIONS. (Illustrated.) 620
DOCKYARD NOTES 621
THE AVONSIDE ENGINEERING WORKS. (Illustrated.) 622
OBITUARY 623
THE OFFICIAL TRIALS OF THE TARTAR. (Illustrated.) 624
RAILWAY MATTERS—NOTES AND MEMORANDA—MISCELLANEA 625
LEADING ARTICLES—Lord Kelvin 627
Coal Price Prospects—Superheated Steam 628
LITERATURE 629
STANDARD NOTATION FOR ENGINEERING FORMULÆ 630
NEW TORPEDO CRUISER FOR TURKEY. (Illustrated.) 630
PRODUCER GAS BOAT TRIALS 630
NEW DOCK AT HONGKONG. (Illustrated.) 631
MANCHESTER ASSOCIATION OF ENGINEERS 631
THE INSTITUTION OF CIVIL ENGINEERS 632
LETTERS TO THE EDITOR 632
FRICTION AND LUBRICATION. (Illustrated.) 633
CONGRESS ON NAVIGATION 634
HIGH-PRESSURE BLOWERS. (Illustrated.) 635
A SMALL ELECTRICITY PLANT. (Illustrated.) 635
A NEW ROAD TRACER. (Illustrated.) 635
BLACKFRIARS BRIDGE ACCIDENT 636
THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS 636
NOTES FROM LANCASHIRE 636
THE SHEFFIELD DISTRICT 637
NORTH OF ENGLAND 637
NOTES FROM SCOTLAND 637
WALES AND ADJOINING COUNTIES 638
NOTES FROM GERMANY 638
PERSONAL AND BUSINESS ANNOUNCEMENTS 638
BRITISH PATENT SPECIFICATIONS. (Illustrated.) 639
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.) 640

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

TAXIMETER.—We believe that the makers of the taximeter as used on most of the London cabs is the Taximeter Company, Limited, of Kennington.

W. B. (Coventry).—We do not know of any experiments which have been made to determine the elastic limit for drawn zinc in compression. We do not think that the information is given in any text-book.

H. N. P.—Try ordinary caustic soda, using about one ounce to every seven or eight gallons of feed-water; but we strongly advise you, if the water is giving trouble, to have it analysed by a good chemist, who will tell you exactly what proportion of lime and soda to use for its purification.

MEETINGS NEXT WEEK.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS: GRADUATE SECTION.—Saturday, December 21st, at 7 p.m., in the Institute Lecture Hall, 4, St. Nicholas'-buildings West, Newcastle-upon-Tyne. General meeting. Paper, "The Behaviour of a Ship's Structure under Stress," by Mr. W. R. G. Whiting, B.A.

THE INSTITUTION OF CIVIL ENGINEERS: ASSOCIATION OF YORKSHIRE STUDENTS.—This evening, Friday, December 20th, at 7.30 p.m., in the Department of Applied Science, The University, St. George's-square, Sheffield. Ordinary meeting. Paper, "The Utilisation of Waste Energy in Iron and Steel Works," by Mr. F. W. Dick.

DEATHS.

On the 13th December, at 5, Pemberton-terrace, Cambridge, LT.-GEN. JAMES JOHN MCLEOD INNES, V.C., C.B., late Royal Engineers, in his 78th year.

THE ENGINEER.

DECEMBER 20, 1907.

Lord Kelvin.

AND so Lord Kelvin is gone! Most of us remember him as the leading man of science all our lives, and to all engineers he has been not merely a great name, but a beloved and respected personality as well. It is very difficult to say what place Kelvin will take with posterity. Physical science is now such an enormous subject that to become eminent a man has generally to confine his attention to some small branch or twig; but Kelvin seemed to be able to deal with the whole subject as one. Helmholtz resembled him, perhaps, more nearly than anyone else. Helmholtz was in the first rank in several directions, but he was essentially the University Professor, and the ophthalmoscope is the only invention of any importance we owe to him. Kelvin's greatest work, and the work by which his name will go down to posterity, is entirely theoretical, and is, unfortunately, largely unintelligible to the ordinary man. We also use the results of his work every day without realising its source, and many things are so easy to understand now that we are apt to underestimate the real difficulties. To understand the nature of logarithms is within the power of a schoolboy, but it has always seemed to us one of the greatest feats of human intellect to evolve the theory of logarithms when as yet there was no calculus. Kelvin's early work on heat was of the same order as Napier's. We start our study of thermodynamics with the absolute temperature scale as a base; to try to realise the feat performed by Kelvin it is necessary to think in terms of an arbitrary thermometric scale with no particular relation to anything; and to get rid of all initial notions of the real relations of heat and mechanical work. Kelvin's greatest work was probably in connection with the second law of thermodynamics.

Kelvin was unique in uniting mathematical ability of high order with its application to physics, and in applying both to the practical problems of engineering. Yet he was by no means exclusively practically minded, even from the scientific point of view. One of the subjects that always interested him most keenly was the ultimate constitution of matter. He advocated the vortex theory, but he was always at work on this subject, and his house was full of models of molecules. This was typical of Kelvin especially, and of the British school of science of which he was head. Continental physicists have long ridiculed, and are now, perhaps, beginning to envy, our insular way of using mechanical models to illustrate what to them is satisfactorily settled by a few differential equations with no concrete signification behind them. Lagrange's pride in the exclusion of all diagrams from his book on analytical mechanics does not appeal to Englishmen generally, and still less must it have appealed to Kelvin.

Then he was always interested in such questions as the age and probable duration of the Earth. On the other hand, he was a practical inventor, and he took enormous interest in all technical applications of science. His inventions appeal more to the public than his pure scientific work, but they are not of anything like such a high order. There are three kinds of inventor—the man who comes on discoveries accidentally, generally when looking for something else; the enthusiast, often a little ignorant, who works at a problem with a kind of instinct, and solves it by a stroke of genius which no one can explain; and the educated technologist, who, finding a door difficult to open, merely selects from the given stock of knowledge the proper key to open it. Kelvin belonged to the last category. His great inventions, such as his compass, his mirror galvanometer, his syphon recorder, and his electrical measuring instruments, all depend on alterations in degree of something that went before. He also developed his inventions by a curious method. He never seems to have been able to sit down and make a drawing of, say, an instrument. He would have an experimental model made from instructions, and would then alter it about until it satisfied him, and then it would be copied as it was. The result was that all his instruments looked as if they ought to be re-designed by a good engineering draughtsman. Kelvin's inventions were often great, but it was because his available knowledge was great, and, though they would be remarkable for an ordinary man, they are really dwarfed by his greatness in other directions.

Personally, Kelvin was beloved by all who had to do with him. You can generally form a sound opinion about a man by noticing the attitude of his old pupils or assistants. We have never yet met an old Glasgow student who did not worship the ground Kelvin trod upon. Many are the anecdotes about him, and some of them will have gone the rounds of the daily Press; but there must be many others not yet published. Lord Kelvin often had difficulty in putting things simply, as all ways of thinking were equally simple to him. Some readers may remember a paper on voltmeters at Section A of the British Association. The point was that if an electrostatic voltmeter has brass quadrants and an aluminium needle it produces a quarter of a volt on its own account. As the instrument follows a square law, so that its scale is crowded up at the beginning and splayed out at the end, the odd quarter volt cannot be noticed when there is no outside pressure, but at 100 volts it can be seen to read $100\frac{1}{2}$ or $99\frac{3}{4}$, and the error is visible. It took Lord Kelvin about half an hour to explain this. Then, as an example, he first squared a quarter, and then proceeded to determine the difference between the square of 100 and of $100\frac{1}{4}$, but he could not get the square of $100\frac{1}{4}$ right. Then the rest of Section A joined in, and made numerous but outrageous suggestions. Finally, the chairman interfered, and the next paper was read. Meantime, Lord Kelvin sat behind the black board on the dais making calculations, and as soon as the other paper was finished he rushed out triumphantly with the calculation achieved. Those who were interested in cycle tire litigation may remember Lord Kelvin giving evidence. It was about a Clincher or a Welch tire, and the judge, Mr. Justice Romer as he was then, said, "Lord Kelvin, I have heard a great deal in this case about the tire being held into the rim. It seems to me it is always being pressed into the rim by the weight of the rider, what is there to make it come out?" "Well my lord, if I were cycling at a very high velocity, and in order to reduce my velocity I was to place my front wheel so as to be at right angles to the direction of motion, I think there would be a tendency to remove the tire from the rim."

One of Kelvin's most astonishing characteristics was his avidity for work. He was as enthusiastic at eighty-three as at twenty-three, and he seemed to work always. He really loved work, and he never tired of it. He was a standing refutation of the theory that a man does no good work after forty. It is much more likely that we all get lazy at forty to forty-five; but those who work hard from forty to fifty without succumbing, remain active all their lives, and probably prolong their active existence considerably. Though he spent most of his working life on scientific problems, Kelvin took interest in all sorts of general subjects. Though not a trained musician he was fond of music. He pointed out, for instance, that a symphony, instead of being imperfectly represented by a full score, might be written as a long, fine, sinuous line, the waves representing every shade of pitch, loudness, and "tone colour" of the most complicated music conceivable.

Kelvin's life was very successful, and, we believe, very happy. To achieve real success demands not

only first-rate abilities, but good fortune in addition. One of the greatest strokes of good fortune was when Miss Blandy heliographed "Yes" from Funchal. We do not discuss the private lives of great men, but the outside scientific world will never know how much we really owe to Lady Kelvin. There can be no doubt that Lord Kelvin's work has been facilitated for many years largely by her relieving him from all matters that she could attend to, and by her tact and great ability, which we can mention, as they are apparent to all; and still more largely by her being a helpmeet in the highest sense of the word to the greatest man of our time.

Coal Price Prospects.

THE announcement of the award of a further increase in the wages of the coal miners in the federated area of England and North Wales does not hold out much prospect of an early reduction in the price of fuel to the numerous consumers who are supplied from the particular coalfields affected by the fresh concession made to labour. The present advance, which has been decided by Lord James of Hereford, the independent chairman of the Coal Trade Conciliation Board, is to date from the first making-up day in January, and it will bring the total rise in wages in the past twelve months up to 20 per cent. The federated area is represented by the coalfields of Yorkshire, Lancashire and Cheshire, the Midlands, and North Wales, which provide employment for over one-third of the total number of coal miners in Great Britain. On the other hand, the coal miners in South Wales and Scotland have received a still higher percentage advance in wages during the present year, and the upward movement has consequently been quite general. The fact that a fresh augmentation has been granted at a time when the condition of trade in the iron and steel, shipbuilding, and certain other industries has become less satisfactory than it was a few months ago may appear remarkable, but the coal trade is always one of the last to participate in a period of prosperity, and the coalowners apparently expect it to be also one of the last to take the descending curve. On the present occasion, the independent chairman has regarded the increased production of coal in the present year, as well as the selling prices, as an important factor in determining the position before the Coal Trade Conciliation Board. A larger output naturally implies the payment of a considerably greater sum in wages, and the miners have already participated in this direction, thus leaving, as it would seem, the question of selling prices alone to decide the situation. However that may be, production and sale prices have been combined for the purpose, and the position has to be faced as it stands.

The facts leading up to the present state of affairs have arisen as a result of the period of general prosperity that has prevailed, and of the promotion of the export trade in coal, especially the latter. An enormous demand has existed for coal for a long time past in certain European markets, notably France, Germany, Holland, and Belgium, but it has been absolutely impossible for the native producers to meet the requirements. The opportunity has not been overlooked by British coalowners and exporters, who have sought to extend their sphere of activity not only for the purpose of finding a market for the larger tonnage raised in Great Britain during 1907, but also with the object of driving out foreign competition where it has gained a foothold. The internal prosperity of France, Germany, and Belgium, although now slightly on the wane, in sympathy with the movements in other countries, has facilitated the cultivation of the British coal export trade, and also the maintenance of high prices in the United Kingdom itself. As far as the foreign trade in coal is concerned, the Board of Trade returns for the first eleven months of the present year show an increase in the exports of 7,000,000 tons over the corresponding period of 1906, and out of this total no less than 5,000,000 tons represent larger quantities which were shipped to France, Germany, Holland, and Belgium as compared with the equivalent term of 1906. The British exports to France alone—which country was an increasing market for German coal year by year between 1898 and the end of 1906—were greater in the first eleven months of 1907 than in any year recorded in statistics; and our exports to Germany in the same months of the current year were also considerably in excess of those obtaining in any complete year on record. How this situation has been assisted by the internal condition of Germany is illustrated by the fact that whilst the production of coal in that country increased by 5,000,000 tons in the first ten months of 1907 as contrasted with the corresponding period in 1906, the exports of German coal merely advanced by the insignificant quantity of 140,000 tons in the same months of the two years respectively. But the industrial position in Germany, leaving Belgium and France out of consideration, is undergoing a material change for the worse, and with the release of the tension the German coalowners will be better able to meet a larger portion of the requirements of their inland market, and also be able to devote increased attention once more to the export trade to France, Holland, and Belgium.

The decline in industrial prosperity on the European Continent will naturally bring about a diminution of the demand for coal from Great Britain, although no indications yet exist which show that a decrease has taken place. But the downward movement would have to be of considerable extent before any hope could be entertained that it might assist in causing inland prices to fall in the United Kingdom. There is, however, nothing to suggest that the retrogression will be other than gradual in its character, and if this assumption be correct it would mean that the prices of coal would also only recede gradually when the winter is over. As it is, the average value of exported fuel in the past three months has not experienced any noteworthy changes, although still being from two shillings to half-a-crown per ton higher than in the corresponding months of 1906. But if export prices decline to any extent, it would be interesting to learn how this can possibly react upon inland quotations in favour of consumers. Wages are already higher, as already mentioned, but the gloomy spot on the horizon lies in the prospect of the Eight Hours Bill being introduced and enacted next year. The coalowners contend that if the measure becomes law it will cause an increase in the cost of production and in the price of coal to consumers, and they are probably correct in their conclusions. If this should prove to be the case, it looks as if no prospects exist of obtaining cheaper fuel for a long time to come, seeing that the possible benefit to home consumers from an abatement of the foreign demand for coal, by a reaction on inland prices, would be counterbalanced by the higher financial charges which would be placed upon coalowners by the operation of an eight hours' day in mines, and which would merely be transferred to the shoulders of consumers in general.

Superheated Steam.

IN our impression for September 13th we dealt at some length with a paper on superheated steam read by Professor A. L. Mellanby before the West of Scotland Iron and Steel Institute, and it will, perhaps, be remembered that we stated that we had not yet received the official report of the discussion. That report now lies before us. Professor Mellanby's paper was so suggestive, and, indeed, so full of controversial matter, that an excellent discussion was to be anticipated. We are disappointed. Only four speakers and Mr. Munro, the chairman, took part in it, and they added practically nothing to the existing stock of information. We have no hesitation in saying that no engineer possessing a fair knowledge of the steam engine disputes that less superheated than saturated steam is required to develop a horse-power per hour. The problem for the dispassionate outsider lies in the fact that, in spite of this admission, the superheater remains we fear we must say unpopular. There must be some reason for this; and we naturally look to discussions on superheated steam as above all other sources of information likely to furnish enlightenment. Little or nothing, however, is to be gathered from the "Transactions" of the West of Scotland Iron and Steel Institute so far. Possibly something may be gained if the position is fairly stated.

In the first place, a great deal of uncertainty on vital points exists. Thus, for example, there is no consensus of opinion as to why superheated steam is more economical than saturated steam. We are told, on the one hand, that there is no thermodynamic reason why it should be better, save one, that it keeps the cylinder hot, and so prevents initial condensation. On the other hand, it is affirmed with equal confidence that initial condensation is a delusion; it does not occur; it cannot, for excellent reasons, occur. The missing quantity is simply leakage, and superheating is economical because it prevents leakage. The perplexed steam user asks why a valve should pass saturated steam and not superheated steam, but he never receives an explanation. Again, he wants to know if it is really possible that in a good, well-kept engine, the valves of which are absolutely tight while the engine is at rest, no less than 30 or 40 per cent. of all the steam going into the engine will leak past them? Very naturally he is incredulous. "But," he reasons, "if this is true, instead of going in for superheating with its various risks, why not make my engine valves tight? That cannot be impossible." Again, he is assured on the one hand that nothing more is required than to superheat the steam, say, 50 deg., so as to be sure that it is dry; and, on the other, that to make superheating worth its initial cost, the steam ought to be nearly red-hot. Who is right? Nor does he find himself on safer ground when he has to determine between the conflicting claims of different superheating systems. Shall he use small pipes or large pipes? Will the waste heat from his boilers do, or must he put up a separate furnace? If he uses the waste heat what becomes of his feed-water? Is that to go cold into the boilers? No definite convincing reply is to be had. The price to be paid for superheating plant at the outset, and for its maintenance, is another vexed question. It is not wonderful, we think, that progress is slow.

The discussion on Professor Mellanby's paper dealt with such questions, and left them substantially unanswered. Professor Mellanby had stated that the chief difficulty with superheaters was that the tubes were raised to such high temperatures that they were either so reduced in strength as to give way at once, or they so rapidly deteriorated as to become a source of danger. But Mr. Stothert assured the meeting that the company which he represented had supplied about 7000 superheaters in various parts of the world, and he only knew of five installations which had given any trouble. As to temperature, Messrs. Belliss and Morcom counted on a saving of 12·5 per cent. for the first 50 deg., and 1·5 per cent. for every 10 deg. subsequently. He gave several other examples to prove that superheating is highly economical—of steam—a proposition which no one disputes. One interesting statement requires elucidation. In a test made at Seraing it was found that certain boilers without superheaters evaporated 8 lb. of water per pound of coal. When superheaters were fitted the evaporation rose to 9·12 lb. Knowing what we do of the quality of Belgian coal, the performance seems very remarkable in more ways than one. His account of what had been done at Sir William Arrol's works would have been useful were it not that he unconsciously presented his hearers with an ingenious puzzle. We gather that there is a single boiler fitted with a superheater which supplies an engine indicating 3000 to 4000 horse-power with steam. This must be a very remarkable boiler.

Mr. Rowan dealt altogether with such questions as radiation, the existence of water in the presence of superheated steam, and the specific heat of steam. Mr. Rickie was practical. He will have no half measures. He holds that the steam should have a temperature of 900 deg. to 1000 deg., with which he has worked wonders in a steam motor car. Professor Mellanby, in his reply, pointed out that even with a superheat of only 200 deg. engines had to be very carefully watched. As to higher temperatures, he directed attention to a paragraph in his paper in which he had shown that the thermodynamic gain from superheating was comparatively small, and its chief advantage that it reduced the missing quantity. In this we concur; but we do not concur when he maintains that the missing quantity is due to valve leakage. He concluded with the following words:—"It was indeed remarkable that practically all their treatises persisted in regarding steam engines as being absolutely free from this leakage, whilst they did not hesitate to attribute enormous initial condensation losses to them in order to account for their measured consumption. He was sure that when once this possibility of valve leakage was fully recognised by writers and experimenters there would at last be a probability of producing a reasonable theory of the steam engine."

There are at the present moment just three men who have adopted the valve leakage theory in its complete form; these are Messrs. Callendar, Nicolson, and Mellanby. Others admit, as a matter of course, that slide valves leak, but this leakage is for all engines worth taking into account quite exceptional. We venture to say that the theory is based on evidence much too slight and too narrow to possess scientific value. We are glad that Professor Mellanby admits that for which we have long contended—the desirability of framing a reasonable theory of the steam engine. It ought, we think, to have already struck Professor Mellanby that it is the manifest duty of those who have advanced a novel proposition to proceed to prove at least its general accuracy. It is a suggestive fact that engines with drop valves, which presumably do not leak, have a missing quantity quite as large as that in slide valve engines, and that they derive at least as much benefit from superheating as does any good slide or piston valve engine. The reply to this argument does not appear to have yet been discovered. We commend the point to Professor Mellanby for consideration.

LITERATURE.

The Practical Design of Irrigation Works. By W. G. BLIGH, M. Inst. C.E., Executive Engineer, Indian P.W. Department (retired). London: Archibald Constable and Co., Limited. 1907.

THE leading feature of this book is the author's critical attitude towards the details of many of the irrigation works, chiefly Indian, of which descriptions have been published in standard works on the subject. He has without doubt devoted much labour to his analysis of the defects and shortcomings which he professes to find in the designs of existing structures, and shows the courage of his opinions by working out alternative plans based on the principles which he advocates.

It is, of course, often a matter of opinion whether the alterations he suggests are to be classed as improvements or otherwise, for he admits in several of his calculations the insufficiency of the data at his command. It therefore appears that perhaps he may not have had the whole case before him, as the authors of the original designs probably had. At the same time he justifies his criticisms by appeal to principles, and therefore to the student his work will be most valuable, and it will, in any case be an instructive exercise to follow his calculations. In some of the cases he suggests the use of reinforced concrete and iron girders, but both of these are of unascertained, if not of doubtful value in irrigation constructions, and certainly such adjuncts were not available to engineers in the earlier stages of irrigational evolution.

In his preface the author claims to instruct engineers unskilled in the irrigation branch of the profession how to use discrimination in the selection of design. This he holds is to be done more by an enunciation of principles and a critical examination of plans of existing or projected works than by "dumping down," as he expresses it, a number of record plans of various works, without remarks on their merits or demerits from the standpoint of modern development. This lays on the inexperienced, it is thought, a heavy onus of selection between theory and practice, for it may be that the opinions of the guide are not always beyond reproach, and he sometimes may not have had the same practical experience and knowledge of the circumstances as the designers of the works.

The book consists of fourteen chapters and a short appendix, among which are distributed 388 illustrations, with eight tables. Many of the latter are original and of considerable value. In Chapter I. the author treats of retaining walls in a satisfactory manner, though perhaps more fully than the subject might be supposed to demand in a work specially devoted to irrigation. In the next chapter on dams, however, his observations on the methods of design of masonry structures are to the purpose of the work, and his treatment of the subject is both good and practical; so also are the next two chapters on weir sections and the proportions of piers, arches, and abutments, as well as on the important question of floors and aprons, of weirs, canal falls, sluices, and regulators. Chapter V. is devoted to a summary of useful hydraulic formulæ and their practical application, accompanied by tables with worked examples.

In dealing with the subject of hydraulic coefficients, the author's observations are well worthy of note. He says in pointing out that Kutter's coefficients are undoubtedly troublesome to work, even with the help of tables, "These general questions of coefficients could easily be set at rest once and for all by experiments on a large scale instituted by the Indian Irrigation Department. The want of proper coefficients applicable to the discharge of water on a large scale through orifices and overfalls particularly is also a crying evil which could easily be settled by proper arrangements instituted by authority, with a practical man in charge who knows exactly what is wanted and how to get at it." These are practical remarks, and we fear it is only too true that the Indian Government is notoriously backward in encouraging the advance of science by experimental research of the kind indicated.

In Chapter VI. is the notable introduction of the author's application of the new theory of "frictional stability" of a pervious substratum. This is scarcely a happy terminology, for with the expression is apt to be associated the idea of the stability of a structure liable to slide on its base under the action of horizontal pressure; whereas here it is, according to the author, the frictional resistance offered to the creep of water through a pervious substratum compressed by the weight of the superstructure, which tends to consolidate the loose material and counterbalance the hydrostatic pressure of the fluid, the action of which is to lift the superincumbent mass, and thus cause failure of the whole. This theory is practically applicable only to works founded on such materials as sand, gravel, or shingle, and its application is practically worked out by the author to submerged weirs and other canal constructions. It is difficult, however to accept all the author's views on this subject, particularly in the matter of the "reduced" specific gravity of the rubble pitching, as it is thought that the specific gravity of a body once determined continues constant. The remaining six chapters treat of the usual subsidiary canal work, and afford much instructive information.

Chapter XIII. is devoted to the important subject of reservoirs and tanks, among the many examples of which are given several from the United States, as well as some of the most recent constructions in Australia and India, represented by the Croton and Coolgardie reservoirs and the Betwa weir. In this chapter is continued the author's methods of placing alternative designs before the reader.

The concluding chapter describes several forms of lifting gear for outlets and draw-gates, and the application of antifriction roller frames to sluice gates of large dimensions, exemplified in the Assouan dam.

The illustrations of the work are inadequately produced, and being sometimes so unconventionally placed on the paper and drawn to so small a scale that they are not as clear as they might be. Though dimensioned in a fairly liberal manner, they lose value for want of scales. There is often some difficulty in following the author's verbal descriptions, which might have been obviated by a fuller use of references with lettering on the cuts. There are some confusions, too, in the references. A good index would have greatly enhanced the value of the publication.

Balancing of Engines; Steam, Gas, and Petrol. By ARCHIBALD SHARP, W.Sc., A.M. Inst. C.E., &c. London and New York: Longmans, Green and Co., 1907.

THE balancing of engines, both steam and internal combustion, is a subject which has received much attention during the last few years. The high-speed steam dynamo, the high-speed marine engine, and, more recently, the motor car engine, have contributed to the necessity of establishing methods of attacking the problem which can be used in practice by the draughtsman and by the designer. The literature of the subject, however, is scanty, and with the exception of Prof. Dalby's standard work on the subject, the information is scattered in the "Proceedings" of various engineering societies. The present work is therefore a welcome addition, and it treats this somewhat complicated subject in as simple a manner as is probably possible. It should therefore be of great use to those who are practically engaged in the design of engines requiring accurate balancing. A purely graphical method has been chosen for the actual working out of each case, but analytical methods have also been used to elucidate certain points. Undoubtedly the comparison obtained by using the two methods helps in understanding the subject. The book consists of fifteen chapters, and is illustrated by means of a large number of figures, which are clearly drawn and lettered; we refer to the lettering because, in our opinion, this is a matter which is frequently insufficiently attended to. The usual custom of numbering the figures consecutively from the beginning to the end of the book has been replaced, however, by the somewhat inconvenient arrangement of numbering the figures in each separate chapter consecutively.

Chapters I. and II. are introductory, and discuss the laws of motion and those theorems in mechanics which are necessary for the understanding of the subject the book deals with. The inertia forces of revolving masses are considered in Chapter III., both when placed in the same plane and in different longitudinal and transverse planes. The method adopted is to draw the polygon of forces in the usual way, and, after assuming a pole to obtain the direction of the vectors, to draw what the author calls the mass—radius—length link polygon, from which it can be determined whether or not the rotating masses are in balance, and if not in balance, what weights are needed, and what their position should be in order to effect a balance. The construction also enables the pressures on the bearings of a rotating shaft to be determined. Reciprocating masses, either alone or combined with rotating masses, are considered in the next four chapters, and it is shown analytically that, when the connecting-rod is of finite length, the inertia forces are represented by the simple harmonic motion that would occur if the connecting rod were of infinite length, to which are superposed the simple harmonic motions due to imaginary cranks with infinite connecting-rods revolving at twice, four times, six times, &c., the speed of the primary crank. The revolving masses for the imaginary cranks diminish rapidly; thus, if the connecting-rod is two and a half times the stroke, the imaginary masses of the second, fourth and sixth orders are 1-20th, 1-8000th and 1-1,600,000th parts of the primary mass, and the corresponding inertia forces are 1-5th, 1-500th and 9-400,000th of the primary inertia forces. The diagrams referred to above are worked out for a number of engines with different number of cranks, amongst which is an interesting engine with five cranks placed at 72 degrees with equal masses on each crank. The author thinks this engine deserves some attention from the manufacturers of motor car engines; its balance is better than that of the four-crank engine, but is slightly inferior to that of the six-cylinder engine; in respect of constancy and kinetic energy of the pistons and connecting-rod it is, however, much superior to the six-cylinder engine.

In Chapter VIII. the graphic method of balancing is applied to V-type engines, that is, to multi-cylinder engines with connecting-rods working on the same crank-pin, such, for example, as the well-known Brotherhood engine. It is shown in this manner that a four-cylinder engine with equal angles (90 deg.) has no unbalanced forces of any order. A five-cylinder engine with equal angles is also investigated, and it appears that its balance and other dynamical qualities are very good. The kinetic energy of pistons and connecting-rods is investigated by an extremely neat graphical method in Chapter IX. The method is such as to be easily applied in the drawing-office. The matter is also investigated analytically, and some useful tables, from which the energy of pistons and connecting-rods can rapidly be calculated, are given. In Chapter X. methods of calculating the torque and the fluctuation of energy are developed, and a table is given showing the ratio of excess energy to the average energy of one revolution in various types of engines, including double and single-acting steam engines and two-stroke and four-stroke cycle gas engines. It is interesting to note that this ratio is the same for a four-cylinder double-acting steam engine, and for a sixteen-cylinder four-stroke gas engine. Chapter XIII. discusses the balancing of a great variety of engines used for various purposes, including vertical and horizontal stationary engines, locomotives, marine engines, and a special feature is made of motor-car engines. A short chapter is devoted to large gas engines from the balancing point of view, and the author contemplates the use of a twenty-four-cylinder six-crank engine for marine purposes, and says that such an engine should compare favourably with the steam turbine in smoothness of running and in absence of vibration. The book concludes with a very elaborate table giving a synopsis of the results. It includes forty-three types of engines, varying from one cylinder to twenty-four, and gives the largest unbalanced force and the largest unbalanced longitudinal couple, the average kinetic energy, and largest variation of this energy for pistons and connecting-rods and the energy fluctuation ratio. Most chapters are followed by examples to be worked out by the student.

Present-day Shipbuilding. By THOMAS WALTON. London: Charles Griffin and Co., Limited.

THIS is a good and useful book, issued at a moderate price, and to those interested in practical shipbuilding and marine engineering it will be found worth having either for information or reference. It is really a reprint, with additions, of some of the best chapters contained in the author's larger and more expensive work entitled "Steel Ships." Very often expensive books are not the most widely read, and therefore not the most useful. Moderation is the golden rule even in the price of a book.

The information contained in the book in connection with practical ship construction is given in clear and plain language, and the illustrations are distinct and numerous. There are four chapters; the two first and the last one deal with such matters as classification societies, the Load-line Act, system of framing, alternate methods of construction, Lloyd's numerals, bulkheads, details of construction, riveting and other details.

The third chapter is divided into two sections; the first section deals with various types of vessels, and the other with descriptions and illustrations of the principal structural features of some noted and also some new types of vessels. A number of questions upon practical ship construction, with brief answers, are also given at the end of the book for the guidance and assistance of students.

SHORT NOTICES.

The Proell Steam Calculator. London: John J. Griffin and Sons, Kemble-street, Kingsway, W.C. Price 5s. Explanatory booklet and three plates.—This little booklet, which is accompanied by three plates, describes the use of the Proell steam calculator. The plates which constitute the calculator are intended to simplify existing graphical methods of thermo-dynamic calculations. On each plate there are eighteen linear scales, which are so arranged and divided that almost all calculations upon the inter-related properties of steam may be performed by merely laying a straight edge across the scales, through two given points, and reading the third corresponding value. The plates also include scales which may be used for obtaining the sections of the nozzles of steam turbines. The three plates are lettered A, B, C respectively. On plate A the scales are divided according to the metric system of units. Plate B has been prepared especially for the convenience of electrical engineers. It differs from plate A in that the scale of total heat is in terms of kilowatt-hours per ton of steam. Plate C is based on British units.

Steel Works Analysis. By John Oliver Arnold and F. Ibbotson. Third edition. London: Whittaker and Co., 2, White Hart-street, Paternoster-square. Price 10s. 6d. net.—In this edition the authors have left out all those operations described in the first edition which the course of time has rendered obsolete, and their places have been taken by descriptions of new and rapid methods and the improvements in processes formerly of only moderate accuracy. The section on gas analysis has been revised and brought up to date. The new matter includes the latest methods for the calorimetry of fuels, and the inclusion of methods for the analysis of bearing metals, such as bronzes, brasses, and white metal. In other respects the book remains as before. The work was originally written especially for assistants in steel works, laboratories, and students taking up the analytical chemistry of iron and steel with a view to becoming steel works chemists. For such it is particularly good. It is practical and sound, and will no doubt prove of considerable value to those for whom it was more especially written.

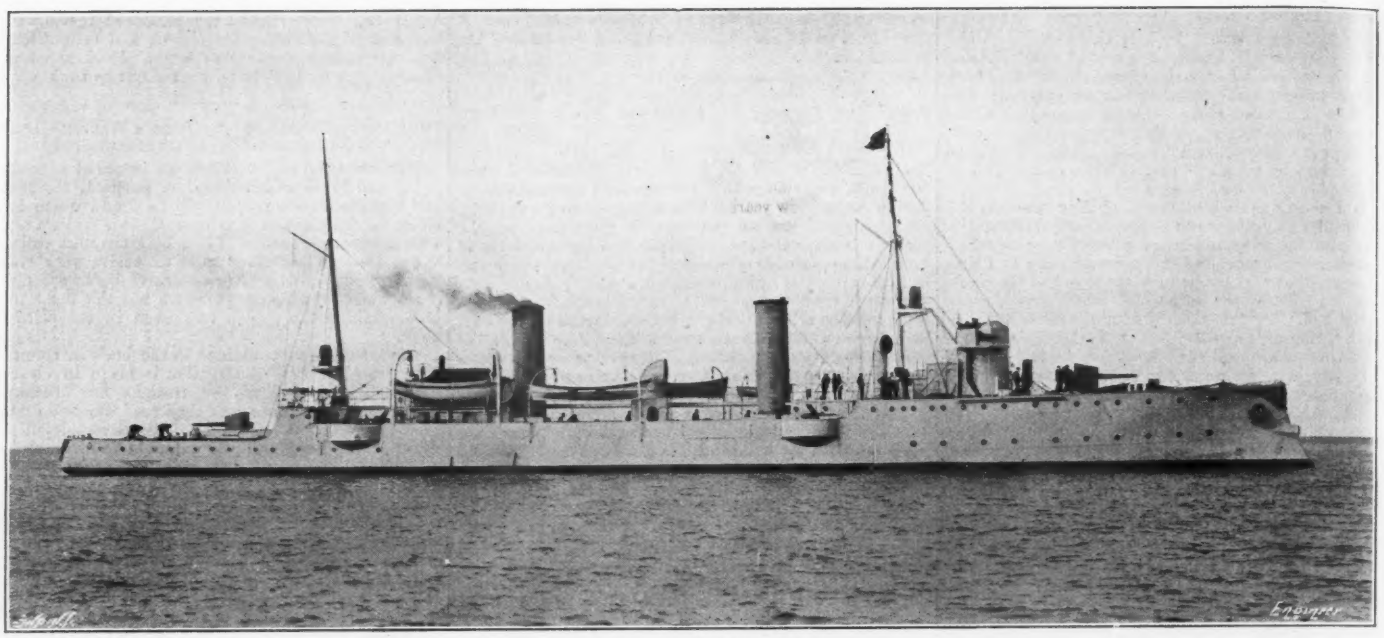
The British Standard Specification for Consumers' Electric Supply Meters. London: Crosby, Lockwood and Son, 7, Stationers' Hall-court, Ludgate-hill, E.C. Price 2s. 6d. In drawing up this specification the Engineering Standards Committee have endeavoured adequately to protect both the purchaser and the manufacturer. The specification is confined to meters of the motor type for use on continuous and alternating-current circuits. It is believed that the conditions laid down in the specification can be attained without undue difficulty or expense, and that the result of the general adoption will tend to a marked improvement in the instruments, as well as the removal of numbers of difficulties which at present hamper the meter industry. We understand that the specification has been prepared after very exhaustive inquiry into the matter, and the committee have confined their attention to those points which, in their opinion, are most necessary to the proper working of a meter.

Guide to Some of the Public Works of Frankfort-on-the-Main. The City Engineer's Department, Frankfort-on-the-Main.—In consequence of the many visits paid to Frankfort-on-the-Main by representatives of other municipalities and specialists from this country and abroad, it has been felt necessary to place at the disposal of visitors a description of some of the public works of this German city. From this book, which is printed in English and French, visitors will be able to gather the most important features, statistics, and information relating to economic data in a more perfect manner than would otherwise be possible during a short visit. This is a smaller guide than that published on the public works of Frankfort-on-the-Main in the year 1903, and it also differs from the earlier work in that it does not go so fully into details, but gives a general idea of the activity and range of duties of the works department.

Road-making and Maintenance. By Thomas Aitken, M. Inst. C.E. London: Charles Griffin and Co., Limited, Exeter-street, Strand. Price 21s. net.—The second edition of this book has just been published. It is certainly one of the best works that have been written on the subject of road-making and maintenance, and gives a very large amount of information. Since the introduction of the first edition the conditions of traffic have been somewhat altered, owing to the enormous development of the motor car traffic. So great

THE TURKISH TORPEDO CRUISER PEIT-I-SHEVKET

FRIED. KRUPP, GERMANIAWERFT, KIEL, BUILDERS



has this change been that the construction of the roads now requires a different treatment from that formerly adopted, and the author's remarks and advice on this most important question is, perhaps, the chief factor of this new edition. Besides numerous half-tone plates and other diagrams, some working drawings, detailed and dimensioned, are given, and naturally enhance the value of a book which is essentially practical.

"*The Practical Engineer*" *Electrical Pocket-book and Diary*, 1908. London: The Technical Publishing Company, Limited, 55 and 56, Chancery-lane, W.C. Price 1s. net.—With the improvements which are continually taking place in electrical apparatus and machinery, it is not surprising to find that the 1908 edition of this pocket-book contains many alterations and additions. In order to make the book meet the present requirements, it has been found necessary, in revising, to make considerable additions. There is now a new table on the cost of overhead cables for transmitting power, some new notes on aluminium conductors, cable section constants for various systems of supply, magnetic clutches, some figures concerning efficiency of generation and depreciation of plant and machinery, electric winding systems for mines, the Osram lamp, thermit welding, &c.

"*The Mechanical World*" *Pocket Diary and Year-book for* 1908. Manchester: Emmott and Co., Limited, 65, King-street. Price 6d. net.—Since the last and twentieth issue of this little book some important changes have been made, and the whole work has been revised and brought up to date. In the present issue the notes on electric transmission have been omitted, and matter of a different character has been substituted. Among the new sections there is one on condensing plants and another on superheated steam. The matter on reverberatory and re-heating furnaces has been re-written and extended. Another new feature to which we may call attention is a section on friction clutches. Several new tables have also been added, which refer to such matters as Morse standard tapers, British standard pipe flanges, pipe threads, &c.

Hydraulic Rams: Their Principles and Construction. By J. Wright Clark. London: E. T. Batsford, 94, High Holborn, W.C. Price 3s. net.—The second edition of this book differs very considerably from the previous edition. The greater portion of the text has been re-written and the subject matter has been re-set and divided into chapters for the convenience of reference. The illustrations have also been re-drawn and other examples have been added, so that the character of the book is now much improved. There are eighteen chapters, which deal with a number of interesting questions associated with hydraulic rams, and the work now constitutes a most useful reference book for practical men engaged in work of this description.

The Navy League Annual, 1907-1908. Edited by Alan H. Burgoyne. London: The Navy League, 13, Victoria-street, S.W. Price: Paper covers, 1s.; cloth, 2s. 6d.; red morocco, £1 1s.—This book, which contains contributions written by a number of eminent men, should prove entertaining to those interested in ships, and matters concerning the British and other navies. The book is divided into twenty-one chapters, which, among other things, deal with the progress of the British Navy, the progress of foreign navies, the work of the Royal Volunteers, the future of the coastguard, gunnery in the Navy, and many other interesting subjects. There is a number of illustrations of British and foreign battleships, and a quantity of information concerning them.

The Metric and British Systems of Weights, Measures, and Coinage. By F. Mollwo Perkins, Ph.D. London: Whittaker and Co., 2, White Hart-street, Paternoster-square. Price 1s. 6d. net.—This little book has been written for students, for business men, and for the general public. It deals with the metric measurements of length, area, volume, and weights. In order to make the book of more general application, especially to schools and polytechnics, a chapter on specific gravities has been included, in which the use of the balance is explained. Arithmetical examples are also included. At the end of the book there are some useful tables of nautical measures, wine measures, comparison of the United States measures with the metric system, screw threads, thermal units, &c.

The Business Encyclopædia and Legal Adviser. By W. S. Knight. Vol. VII. London: The Caxton Publishing Company, Clun House, Surrey-street, W.C. Price, 7s. 6d.—This is one of a series of books forming an encyclopædia for business people. In this volume accounts and account-keeping are dealt with fully and different systems are carefully explained. The greater part of the work, however, is given over to the question of science of advertising—if one may be permitted to call advertising a science. The different sections of the book have been written by well-known authorities on their respective subjects, whose advice should at least be worth consideration

BOOKS RECEIVED.

Proceedings of the Sydney University Engineering Society, 1906. Sydney: F. Clark, 1-3, Rowe-street.

A Manual of Fire Assaying. By Charles Herman Fulton. London: Hill Publishing Company, 6, Bouverie-street, E.C. Price 8s. 6d. net.

Der Neue Leitfaden: The Student's First German Book. By L. M. De La Motte Tischbrock. London: John Murray, Albemarle-street, W. Price 2s. 6d.

Handbook of American Gas Engineering Practice. By N. Nisbet-Latta. London: Archibald Constable and Co., Limited. Price 18s. net.

The Principles of Railway Stores Management. By William Oke Kempthorne. London: E. and F. N. Spon, 57, Haymarket. Price 10s. 6d. net.

Westminster Series: Coal. By James Tonge. London: Archibald Constable and Co., Limited, 10, Orange-street, Leicester-square, W.C. Price 6s. net.

Westminster Series: Town Gas and its Uses. By Wm. Hosgood Young Webber. London: Archibald Constable and Co., Limited, 10, Orange-street, Leicester-square, W.C. Price 6s. net.

La Construction D'une Locomotive Moderne. By Dr. Robert Grimshaw and P. Poinsignon. Paris: Gauthiers Villars, Quay de Grands Augustins 55.

Nautische Bibliothet Elementare Schiff-fahrtfunde. By Professor Dr. Bolte. Berlin: Konrad W. Mecklenburg, Vormals Richter'scher Verlag, Motzstrasse 77. Price Mark 1·50.

STANDARD NOTATION FOR ENGINEERING FORMULÆ.

THE following letter has been circulated by Mr. A. S. E. Ackermann, the hon. secretary of the Civil and Mechanical Engineers' Society:—

The experience of engineers and others who have frequent occasion to use engineering formulæ is that much inconvenience, loss of time, and unnecessary mental effort, and many mistakes are caused by the prevailing lack of uniformity in the symbols employed by authorities for denoting various factors occurring in the formulæ and calculations relating to all branches of engineering work.

Realising the desirability of drawing attention to this question and of affording to all who are interested in it an opportunity of expressing their views, the President and Council of this Society have arranged to devote the ordinary meeting at Caxton Hall, at 8 p.m., on January 2nd, 1908, to a discussion, to be opened briefly by the President, on the subject of "Standard Notation for Engineering Formulæ," in the hope that the opinions and suggestions then brought forward may pave the way for a conference under the auspices of all the leading engineering institutions, societies, and associations, and that the ultimate result may be a reform the practical value of which it would be difficult to over-estimate. The object of this letter is to ask whether you will co-operate with the Council in the movement by contributing a written statement of your views, accompanied by a schedule of the standard symbols which you recommend.

If a sufficient number of the schedules of symbols are received it may be possible for us to get out a tentative "standard schedule" of symbols, each of which has received the largest number of "votes" for its particular purpose or purposes, for some symbols have more than one well-recognised use, owing to the necessity of providing for the formulæ belonging to different branches of engineering.

As arrangements have to be made well in advance of the date mentioned, I shall be glad to have a reply at your early convenience.

(Signed) A. S. E. ACKERMANN.

25, Victoria-street, Westminster, S.W.

NEW TORPEDO CRUISERS FOR TURKEY.

THE illustration given herewith shows one of the two new Turkish gunboats, the Peit-i-Shevket ("His Majesty's Messenger") and Berc-i-Satvet ("The Lightning of Force"), which were laid down at the end of 1906 and delivered in October last, after a series of satisfactory trials. Peit-i-Shevket and her sister ship, which were built by Fried. Krupp, A.G. Germaniawerft, Kiel, are now on their way from this harbour to Constantinople. On general lines they embody an improved design of the old torpedo gunboats Pelenk-i-Deria and Namet. Their principal dimensions are:—Length, 262ft.; breadth, 27ft. 6⅔in.; draught, 8ft. 2⅔in. Their displacement in normal load condition is about 740 tons, their coal supply 240 tons. At speed trials they attained one knot more than the contracted 22 knots. They are armed with two 10·5 cm. (4in.), six 5·7 cm. (2¼in.), two 3·7 cm. (1½in.) guns, all Krupps, and five Hotchkiss quick-firing guns. Torpedo armament: One bow tube and two deck tubes, one on each broadside, all for 18in. torpedoes.

PRODUCER GAS BOAT TRIALS.

WE have received from Crossley Brothers, Limited, particulars of some interesting tests which this firm has recently made in connection with the propulsion of canal boats by means of a specially designed engine using suction gas. The gas plant was fitted into a boat built by the firm of Fellows, Morton and Clayton, Limited, and the trials were conducted on the canal between Birmingham and London, with a view to testing the capabilities of this method of propulsion when operating continuously for lengthy periods. The gas boat was loaded with cargo, and also towed another boat in the manner which is customary with steam boats. Tests were carefully made to ascertain the consumption of fuel, and the following particulars show a remarkable economy under this heading.

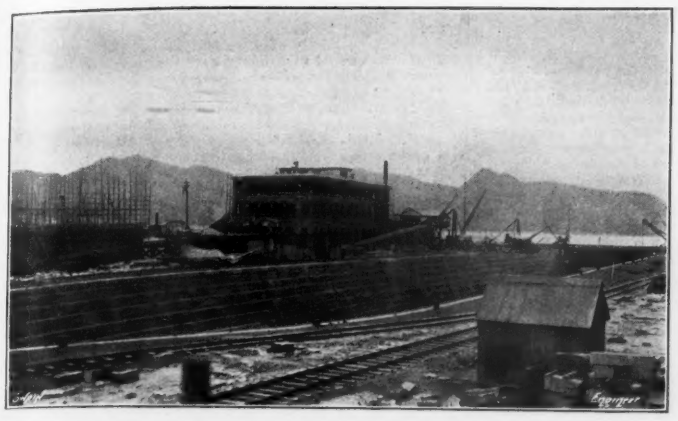
The gas boat left Birmingham at 11.30 p.m. on 2nd December last, loaded with a cargo of 15 tons, and upon arrival at Braunston—43 miles from Birmingham—a butty boat loaded with a cargo of 22½ tons was taken in tow; London—Brentford—was reached at 9.30 a.m. on 5th December. The total journey occupied 58 hours, being the same length of time as is taken by the regular steamers; and the suction gas plant with the engine having been in operation for sixty hours continuously. The engine is of the vertical enclosed type, designed to work at comparatively low speeds. It has two cylinders, and develops about 14 brake horse-power. At the commencement of each journey this engine is started by means of compressed air contained in storage tanks, and runs without stopping until the completion of the journey. Clutch gear is provided for driving the boat either ahead or astern, this being controlled by the driver of the boat.

In making the test for fuel consumption the producer was filled with anthracite fuel at the commencement of the trial, and left in the same condition at the finish. During the sixty hours which the plant was in operation, the total weight of fuel passed into the hopper amounted to 661 lb. No allowance has been made for the removal of clinker, or for moisture in the coal:—

Total length of trial	60 hours
Cargo in gas boat (Birmingham to London)	15 tons
Cargo in butty boat (Braunston to London)	22½ tons
Total	37½ tons
Length of journey	138 miles
Number of locks passed through	141 locks
Total fuel used during 60 hours	661 lb.
Pounds of fuel per mile $\frac{661}{138}$	4·8 lb.
Pounds of fuel per hour $\frac{661}{60}$	11 lb.
Total cost in fuel for trip at 25s. 5d. per ton	7s. 6d.
Cost of fuel per mile	·65d.

The anthracite fuel used for this trial was of a very small variety, and cost 25s. 5d. per ton, and we have Messrs. Fellows, Morton and Co.'s permission for stating that the saving in the cost of fuel, as compared with the steamers using coke fuel, amounts to nearly 50 per cent.

A NEW DRY DOCK AT HONG KONG



THE QUARRY BAY DOCK

THE WORKS AND ENTRANCE TO HON G KONG HARBOUR

NEW DOCK AT HONG KONG.

THE shipping industry in Hong Kong is advancing by leaps and bounds, and it became evident some time ago that increased dry dock accommodation would have to be provided. Two docks were accordingly constructed, and those were recently publicly opened. The smaller of the two has been built by the British Navy, and is of sufficient size to berth the Dreadnought. This naval dock will, of course, be devoted to the service of warships, and will not greatly affect commerce in the Far East.

With the second, known as the Quarry Bay Dock, it is quite otherwise, and it will have the greatest possible bearing on trade. Its construction is the result of private enterprise, and considerable engineering difficulties had to be overcome in its construction. Hongkong is singularly unblessed by Nature with sites for works of any description; and, in fact, the only way to make roads, or get even sufficient level ground on which to build a house, is by reclamation or excavation. No place could possibly have looked a less likely spot, five years ago, for the construction of a dock than the precipitous mountain headland which ran out into the sea at Quarry Bay Point.

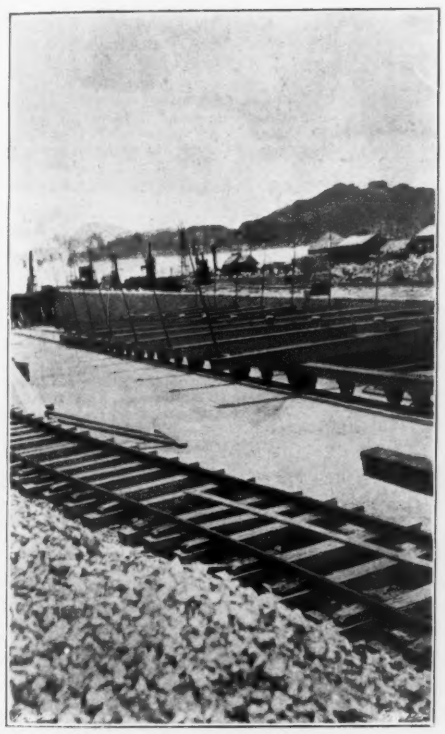
Labour, however, is the cheapest commodity in China, and an army of coolies have levelled the mountain to the ground. Like ants they worked on it—men, women, and children—and the not unmusical quick tap of the hammer on the ringing granite became one of the sounds which were listened for as Quarry Bay was approached. The granite thus hewn from the mountain has been used in the construction of the dock, the slipways, and all the immense works appertaining to a large shipbuilding and repairing yard, and the result, even in its present unfinished state, presents an appearance of solidity and beauty that is remarkable. One does not associate beauty with engineering works usually, but the blue-grey granite reflects the sunshine, and the unsightly look of works in course of completion is wholly lacking here. By reclamation and the excavation 1,600,000 cubic yards of material (51½ acres) of land have been added to the service of man, and three parts of the foundations of the works are of solid granite.

The dock itself is the largest in the Far East, being 787ft. long on the coping and 750ft. on the keel blocks, with a width at the top of 120ft. in the centre and 83ft. 6in. at the bottom. It is built of cement concrete faced with granite, and is closed at the entrance with a sliding steel caisson weighing 400 tons.

On the southern side of the dock three large slipways are in course of completion. Slipway No. 1 is claimed to be the largest in the world, and is 1030ft. long and 80ft. wide.

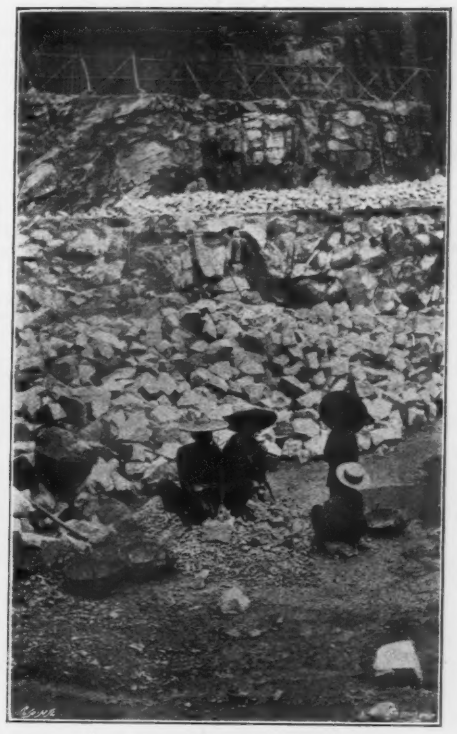
"It is very difficult," says the correspondent who sends us the photographs from which our engravings have been prepared, "for Westerners to realise the up-to-datedness in engineering matters of these far-distant Colonies, and one certainly finds it hard to associate the new Quarry Bay Dockyard with a small island off the China coast."

There are no docks in Japan, the Straits Settlements, or the Philippines that can in any manner compete with this latest addition to Far Eastern facilities, and the new dock cannot fail to have the very greatest influence on commerce between East and West.



THE LARGEST SLIPWAY

END-ON VIEW OF DOCK



BREAKING UP A GRANITE HILL

MANCHESTER ASSOCIATION OF ENGINEERS.

FOLLOWING immediately after Dr. Nicolson's excellent paper on "Friction and Lubrication," the paper which was presented to the members of the Manchester Association of Engineers last Saturday, by Mr. D. M. Nesbit, on the "Ventilation and Warming of Workshops," suffers very greatly by comparison. The subject which Mr. Nesbit had elected to write upon is one which, if properly treated, has a peculiar interest for master engineers and foremen. But the author dealt with the principles of ventilation and warming rather on the lines of a very elementary text-book than in a form calculated to engage the attention of a society of eminently practical engineers. There was little or nothing original in the matter brought before the meeting, and it seemed as though the paper had only been thrown together with a view to advertising a particular system of heating which is not yet very widely known. Unfortunately—or fortunately—the author was unable to be present to hear some of the hard things which were said of his contribution to the Society's proceedings, and Mr. Atkinson, who undertook to read the paper, had a somewhat thankless task, which he may be said to have performed satisfactorily. His verbal explanations and enlargements were the redeeming feature of the paper. The author, after briefly touching upon some of the most used systems, went on to describe a system known as the "Nuvacuumette," which he claimed to be the first automatic low-pressure vapour system to exert entire control over the warming agent, and to obtain definite results under given conditions. In other words, it is claimed to afford a means of supplying heat in direct relation to the rate of condensation proceeding beneath the heating surfaces. The apparatus required includes a vacuum pump in large installations, but it can be dispensed with it in small plants. The important feature of the system is that each radiator can be regulated so as to diffuse whatever degree of warmth may be desired. This regulation of the temperature is effected by means of a special valve placed at the inlet side of the radiator, in which the two metals nickel and copper, with their highly different coefficients of expansion, play a prominent part in controlling the flow of steam according to the amount of condensation which takes place. The author claims many advantages for the system, namely:—Varying vacuum to suit the variations of external temperature; the low temperature of the heating surfaces giving a result similar to the hot water system; the absence of valves on the return end of the radiators; prevention of water hammer; and the freedom of the piping from entrained water, thus preventing their freezing in frosty weather. In the discussion which followed, the elementary nature of the paper, and the manner in which it had been prepared, were somewhat severely criticised.

A NEW BRITISH INDUSTRY.—Calcium carbide, for use with acetylene lamps, requires large power for its manufacture. It is now imported mainly from abroad, where cheap water power is obtainable, but it will shortly be manufactured in this country, at works adjoining the Yorkshire Electric Power Company's generating station near Dewsbury. It is one of the many new and old industries which have been attracted to the districts served by the company's mains, which will provide the necessary current up to several thousands of horse-power required for the manufacture of the carbide at a price which it is estimated will compete successfully with that made with the cheap water power obtainable abroad. It is expected that the works will be in full operation early next year, and considerably increase trade in the district.

THE INSTITUTION OF CIVIL ENGINEERS.

THE PREDETERMINATION OF TRAIN RESISTANCE.

AT the ordinary meeting on Tuesday, December 10th, Sir William Matthews, K.C.M.G., President, in the chair, the paper read was "The Predetermination of Train Resistance," by C. A. Carus-Wilson, M.A., Assoc. M. Inst. C.E. The following is an abstract of the paper:—

The first section deals with the form of the resistance equation. The different elements of train resistance are considered, namely, journal friction, rolling friction, track resistance, flange action, and air resistance. Each element of resistance is given in terms of the known variables, and existing experimental results bearing on the question are reviewed. The conclusion is arrived at that the component parts of train resistance may be divided into three groups distinguished by their relation to the speed. The resistances in group 1 are independent of the speed, and include journal friction, rolling friction, and track resistance. Group 2 includes the resistance caused by flange action, which varies as the first power of the speed. Group 3 includes all forms of air resistance, which vary as the square of the speed. The resistance equation is thus shown to be of the form $R = A + Bv + Cv^2$.

The second section is devoted to the determination of the constants in the resistance equation. The different methods of making train resistance tests, and the errors to which they are liable, are considered. For the purpose of determining the constants the author selects the tests made by Mr. Barbier on the Northern Railway of France as being the most complete and reliable tests of which full records have been kept. These tests were made on two classes of rolling stock, namely, four-wheel and bogie coaches, and a comparison of the results obtained in the two cases, as represented by curves which are reproduced in the paper, furnishes a means of arriving at the constants in the resistance equation. These constants depend upon the type of rolling stock under test, and formulas are deduced by which the constants for any given type of rolling stock may be obtained.

In the third section the resistance formulas are applied to a number of different cases in order to ascertain how far they afford a correct predetermination of the resistance of trains made up of rolling stock entirely different from that tested on the Northern Railway of France. For this purpose a number of the most reliable tests available are selected, the resistance is computed by the aid of the formulas, and the resistance curve is then obtained and compared with the results of each test. The tests considered are the following:—

(1) Tests of bogie coaches on the Lancashire and Yorkshire Railway.—These coaches differ materially from those tested by Mr. Barbier. The curve obtained by the application of the formulas shows a close agreement with the test results, the mean difference at eight selected speeds from 10 to 80 miles per hour being 3 per cent. (2) Tests of four-wheel goods wagons on the London and North-Western Railway.—Here the calculated resistance is 5 per cent. below that obtained by test. (3) Tests on eight-wheel bogie goods wagons on the New York, Ontario and Western Railway.—The calculated value is 8½ per cent. less than the observed value. (4) Tests of eight-wheel electric motor-coaches made by the St. Louis Electric Railway Test Commission.—The resistance obtained from the formulas shows a close agreement with that obtained in the test. (5) Tests of twelve-wheel high-speed bogie coaches at Zossen.—The calculated resistance differs from the test value by a constant amount of 100 lb., being a difference of 7½ per cent. at 60 miles per hour.

In the fourth section the following practical questions are discussed in the light of the conclusions arrived at:—

(1) Journal friction in its relation to train resistance and its possible reduction by roller bearings.—The real value of roller bearings in railway traction is shown to lie in the reduction of running resistance and consequent saving of energy, and not in the reduction of starting effort. The results of tests with roller bearings on the Eastern Bengal State Railway are given, the saving actually obtained being 1 per cent. greater than that calculated by the use of the resistance formulas.

(2) The influence of the truck on the resistance of bogie coaches.—The resistance of a coach is shown to depend largely upon the wheel base of the truck, and the relation of the weight of the bogie trucks to that of the whole coach.

(3) The effect of electrical driving on the resistance of bogie coaches.—The weight of the motors and the extra weight of the motor trucks in electrically-driven coaches increases the flange action and the total resistance of such coaches. The resistance of electrical motor coaches is in some cases as much as 54 per cent. greater than that of trailing coaches running at the same speed under similar conditions.

(4) The reduction of the resistance of goods wagons by the use of bogies.—The influence of the bogie on train resistance is shown to be greatest in the case of goods wagons.

(5) The relation between the tractive efforts required to haul loaded and empty bogie goods wagons.—Since flange action depends upon the ratio of the weight of the bogie to that of the whole wagon, it must follow that the resistance per ton of a loaded bogie wagon must be less than that of the same wagon empty. This is a matter of general experience, and can only be explained on the above hypothesis. The results of tests are given in which a train of bogie wagons was hauled over a considerable distance backwards and forwards, first loaded and then empty. The ratio of the mean drawbar pull in the two cases was 0·56. When the resistances are calculated by the formulas, the ratio is found to be 0·62.

(6) The incidence of train resistance on flange and rail wear.—The energy expended in overcoming flange resistance is represented by the wear of tires and rails. Tables are given to show how much greater this wearing action is in some cases than in others.

(7) The reduction of flange action by mechanical contrivance.—It is shown that by giving the bogie a lead, as is done in Timmis's bogie lead, the flange action of the bogie can be reduced, and that the saving depends upon the ratio of the bogie wheel base to the distance between the bogie centres, and also upon the ratio of the bogie weight to the total weight.

(8) The effect of side play on train resistance, and its possible limitation.—The amount of play between the flanges and the rails is an important factor in train resistance. The want of uniformity in current railway practice in this matter is illustrated by a table giving the amount of side play adopted on thirteen different railways in Great Britain, in the United States, and on the Continent. The increased resistance and wear occasioned by large flange play suggests the importance of a reduction of the play to a standard ⅜in. as on the London and South-Western and other railways.

(9) The relative importance of air resistance.—The resistance of the air with a train of bogie coaches, running at 60 miles per hour, amounts to about one-half of the total tractive effort required to haul the train. The experiments conducted by the St. Louis Electric Railway Test Commission show that a large reduction can be made in the front and rear air resistance by shaping the ends, and that by this means a saving can be effected of 10 per cent. of the total tractive effort with a long passenger train, and 30 per cent. with a single coach.

INDEPENDENT fire protection for its yards and buildings at Pittsburg and Altoona has been secured by the Pennsylvania Railroad, by equipping its shunting engines in those yards with fire pumps and hose. A system of whistle signals indicates the position of the fire and the engine crews are trained in the use of their fire-fighting apparatus. At a recent fire nine engines were at the fire within seven minutes after the alarm.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE VIBRATION OF SHIPS.

SIR,—Your article on the vibration in ships refers to a subject in which I have taken special interest. Is it not true that the increased vibration annoyance in modern large passenger steamers is in some considerable degree due to the very large sizes of their saloons, which diminish the relative stiffness, as distinguished from strength, of the structure of the hulk? Many passengers prefer the old-fashioned slower ships on account of their comparative freedom from this nuisance, and in these the saloons are smaller in proportion to the leading dimensions of the vessel. Suppose that a main section of the ship may, in respect of strength, be considered as a beam of span L, supported in some definite manner—not, of course, "freely supported at the ends." The loads are many and complex, but we may suppose that a resultant maximum load W has been found for the purpose of design. The maximum bending moment will be in some specific proportion to $W L^2$, the proportion depending upon the manner of distribution of the load. This moment will also have a definite proportion to $\frac{k I}{H}$, where k is the edge-stress due to the bending moment, I the moment of inertia of the section, and H the "depth" of the section. As the section considered runs right through the hulk, this depth H is fixed quite irrespective of strength, being, in fact, determined by the beam and draught of the ship; and the designer has, therefore, to obtain the required strength by making (with a given H) $I \propto \frac{W H L^2}{k}$, the value of k being also fixed by the quality of the steel. Now, under any other load w, applied in any specified manner, the deflection caused by w can be shown to have a fixed proportion to $\frac{w L^3}{I}$. This deflection is thus proportional to $\frac{w}{W} \cdot \frac{L}{H}$. Here w may be considered as the force producing the annoying vibration; and, in whatever way this originates, the magnitude of the force is hardly likely to be affected by the relative size of the saloons; nor does this size affect H. For ships of the same length, beam and draught, if the size of the saloons affects W, the influence will be in the direction of making W less, with larger saloons for those parts of the vessel in which these saloons are situated, while L evidently increases with the fore-and-aft length of the saloon.

Thus the effect of designing the ship mainly for strength under maximum normal loads W is to introduce extra local deficiency of stiffness, *i.e.*, greater amplitude of vibration, as against any forces, and in particular as against those producing vibration, when large open spaces are left such as those demanded for modern saloons.

It may be said that the vibration is felt more in the cabins and confined spaces than in the saloons; but this by no means disproves that it originates as one of large amplitude and energy in the walls, floors, and roofs of the saloons.

In your article you refer to the want of balance between the propeller blades as one possible cause of vibration, and you suggest that good balance adjustment in air may be upset when the propeller is submerged because of cavities and differences of density in the metal. The difference of balance in air and in water is a matter purely of gravity or weight balance; whereas the dynamic, or centrifugal-force, balance, which is required for absence of vibration, has to do solely with mass, and is unaffected by the buoyancy, greater or less, of the parts when submerged. The mass balance is best approximated to by a weight balance in air, as the buoyancy in air is minutely small. Still, it is interesting to note that if a weight balance in air—and, therefore, also a mass balance—is obtained in spite of non-symmetrically distributed cavities in the metal, then this infallibly means differences of blade thickness and of general form—*e.g.*, inequalities of pitch angle on front or back surface of the blades at corresponding opposite points, and these again mean inequalities of resistance to the high-speed passage of the blades through the water. Whether such differences of water resistance due to cavities combined with perfect mass-balance would be at all sufficient to account for any measurable portion of the vibration actually observed I am quite unable to suggest.

It seems to me that observation of the wake behind a vessel proves that the whole dynamic action upon the water is rhythmical. The wake is a series of whirlpools. These vortices are extremely complex, and are seldom very steady, but there are nodes in the complexus, and, in steady running through steady weather conditions, these nodes are spaced fairly uniformly apart. The amount of energy wasted in these whirlpools ought to be the saddest subject of contemplation to the marine engineer.

Streatham, S.W., December 14th. ROBERT H. SMITH.

SIR,—Certain small sailing vessels which I have been on vibrated badly when travelling at a fair speed. The vibration seemed to be caused by the rudder, as it ceased at once if any change of helm was made.

December 14th. RICHARD SLATER.

THE STRENGTH OF RINGS.

SIR,—This problem appears to have resulted in as many different formulæ as there have been correspondents, and it is to be hoped that by mutual assistance your readers may be able to come to a general understanding.

Your correspondent in this week's issue, "W. B.," arrives at the result that the maximum stress occurs at the point of application of the load, and not at the ends of a perpendicular diameter, the value of B M being 0·318 W R.

Now, if I have correctly understood Messrs. Moyle and Wells, it appears to me that "W. B." has made a serious error in that, whilst he has reversed the point under consideration, he has not reversed the loading. The half-ring may be considered as loaded at A by W, and re-acted on at B by $\frac{W}{2}$ or loaded at B by $\frac{W}{2}$ at each end of diameter, and re-acted on at A by W. In other words, he has changed the sign of only one part of his formula instead of both. It seems to me that, since the stresses in the ring are reversed as between points A and B, both parts of the formula $B M = \frac{W R}{2} - \frac{W R}{\pi}$ should have their sign reversed, *i.e.*, that the formula should be $- \frac{W R}{2} + \frac{W R}{\pi}$, and that the angle θ should be the complement of the angle taken by "W. B."

Messrs. "W. B." and F. R. S. Rice assert by arguments that do not appear convincing that the maximum stress occurs at the crane hook. If so, why does not the ring distort most at that point? My limited experience of distorted rings tells me that the point of maximum distortion is not under the crane hook, but at right angles to it.

Of course, it will be seen that I am arguing on the assumption that the point of maximum stress corresponds to the point of maximum departure from a true circle, and assuming that a truly circular form exists to begin with.

With Mr. Rice's letter I cannot deal, since in the first few lines he commences by assuming the truth of an argument resulting in certain formulæ, and at the end of his letter assumes that the argument is too simple to need statement. As I have not the paper by me, I cannot follow him. GEO. T. PARDOE.

Angmering, December 14th.

FRICTION AND LUBRICATION.

SIR,—Judging by his remarks, your correspondent "J. B. C." has never read—hardly even glanced at—my paper. Replies to his difficulties would have automatically appeared had he done so; and any lengthy occupation of your space in answering him is therefore unwarrantable.

"J. B. C." says,—"Practice has shown that there is a given length of bearing which for long shafting will run cool with a given speed." An equally illuminating remark would be:—Practice has shown that a steel bolt of one square inch area will safely sustain a working load of one ton.

What I have tried to show in my paper, in addition to the above, is that there is a fixed lower limit for the area of a bearing beyond which we cannot go without danger of squeezing out the oil film, and to give formulæ for that area.

I do not say, however, that this lower limit is the proper size to make the bearing, any more than "J. B. C." would agree to reduce the above bolt to $\frac{1}{3\frac{1}{2}}$th of a square inch for a working load of one ton.

Just as the knowledge of the tenacity of a material in the testing machine enables us to fix upon its safe working load, so the working proportions of journals ought to be capable of determination relatively to some definite or failure condition, depending on oil used, load, and speed.

We have never yet had rules for finding the film-breaking pressure in a bearing under the various conditions of practice. The deductions made in the paper under discussion, from experiments with actual bearings, supply this want—at any rate, for bearing under constant loads—and therefore enable us to state what the "factor of safety" will be with a given design.

As mentioned in the paper, I have not yet dealt with bearings in which the load is being continuously reversed, or in which it is being varied between nothing and a maximum every few seconds. The latter is what happens in the case of "J. B. C.'s" example of the tin mill; and the former is the case with "J. B. C.'s" torpedo boat engine bearings. JOHN T. NICOLSON.

December 16th.

CURTIS TURBINE AT SEA.

SIR,—The editorial in your issue of November 8th, 1907, on "The Curtis Turbine at Sea," expressed a desire for additional information on certain items, and I am pleased to give you the following:—

In the Curtis type of turbine the radial clearance—that is, the distance from the end of the blades to the casing—does not affect the steam economy, and can be made as large as desired for mechanical reasons, being from ¼in. to 2in. in the case of the Creole. The axial clearance—that is, the distance between the sides of the moving and stationary blades—is limited by the fact that, if it is made too large, the steam jet issuing from the nozzles or guide blades will become somewhat broken and irregular before it enters the moving blades. On the Creole the axial clearance varied from 0·1in. for the high-pressure wheels to ¼in. for the low-pressure. These values were considered ample for mechanical reasons, and the jet disturbance produced is practically inappreciable.

The following are the observed pressures at full power in the various stages:—

Steam chest	..	252·7	lb. per sq. in. absolute,		74·5	deg. Fah.	superheat
1st stage shell	..	82·1	,,	,,	59	,,	,,
2nd	,, ..	44·4	,,	,,	30	,,	,,
3rd	,, ..	22·7	,,	,,	24	,,	,,
4th	,, ..	11·5	,,	,,	Moisture unknown		
5th	,, ..	7·6	,,	,,		,,	
6th	,, ..	3·4	,,	,,		,,	
7th	,, ..	1·18	,,	,,		,,	
Condenser	..	·89	,,	,,		—	

The turbine is designed to have one-fourth of the total available energy of the steam apportioned to the wheel in the first stage, and one-eighth of the available energy in each of the six remaining stages. The above-given observed pressures vary somewhat from those required to give this energy distribution, but it is found by experiment that a comparatively large irregularity from even energy distribution has but a very small effect on the total economy; therefore the pressures as observed are considered quite satisfactory.

With equal energy distribution, the velocity of steam flow from one stage to the next through the nozzles in the diaphragms would be the same for all stages. However, in any one stage, the velocity of the steam jet diminishes as it passes through the moving blades, since each row of moving blades extracts approximately twice its own velocity from the jet. This is the "diminished velocity" referred to in my paper, and what you apparently misunderstood as applying to the velocity of flow through the nozzles.

Quincy, Massachusetts, CHARLES B. EDWARDS.
December 4th.

THE RAILWAY CLUB.—The next meeting of the Railway Club will take place at 92, Victoria-street, S.W., on Tuesday, January 14th, at 7.30 p.m., when Mr. R. E. Charlewood will read a paper entitled "Cross-country Train Services."

ROYAL INSTITUTION OF GREAT BRITAIN.—A Christmas course of illustrated lectures, adapted to a juvenile auditory, on "Astronomy, Old and New," will be given by Sir David Gill, K.C.B., LL.D., D.Sc., F.R.S., M.R.I. Lecture 1, Saturday, December 28th, 1907; lecture 2, Tuesday, December 31st, 1907; lecture 3, Thursday, January 2nd, 1908; lecture 4, Saturday, January 4th, 1908; lecture 5, Tuesday, January 7th, 1908; lecture 6, Thursday, January 9th, 1908. Lecture hour, three o'clock.

THE JUNIOR INSTITUTION OF ENGINEERS.—At a recent meeting of this Institution, held at the Society of Arts, the chairman, Mr. Frank R. Durham presiding, a paper entitled "Some Notes on Arc Lighting," by Mr. William Krause, was read and discussed. The author first compared the position of arc lighting of to-day with that of ten years ago, the special features of the open and enclosed types being pointed out. The development of the former was apparent from the increase in the number of lamps for public lighting; by the year 1907, out of 428 stations giving returns, 280 reported public arc lighting with a total of 23,134 lamps. The open type was, however, now on the wane, and there were indications that it would eventually become quite obsolete. With reference to the enclosed type, the author touched upon the various systems of control, and considered that for internal lighting that lamp would maintain its position for some time to come. The inverted arc system of reflection gave excellent illuminating results, but its cost, which was about 40 per cent. greater than that of direct lighting, limited its application. Dealing with the composition of carbons, the different effects produced in the colour of the light by the introduction of various salts and metals were described, and consideration given to questions relating to the arrangement of the carbons. Comparisons of mean hemispherical candle-power of different types of lamps followed, after which some notes on flame arc lighting were given, and the paper concluded with a plea for the introduction of a two-colour light standard. In the discussion which ensued, Messrs. A. W. Marshall, C. H. Smith, C. G. Evans, M. H. Hankin, H. E. Angold, B. Brooks, F. D. Napier, W. T. Hogg, A. H. Stanley, R. H. Parsons, and the chairman took part, and the proceedings closed with the usual vote of thanks.

FRICTION AND LUBRICATION.*

By Dr. J. T. NICOLSON.

No. II.†

UPON further examination of the experimental results plotted as curves upon Fig. 5 and Fig. 6, we observe that for speeds below about 20ft. per minute the coefficient of friction diminishes for a little in exact proportion to the speed, but that the effect of the relatively great excentricity of the journal in the bush soon begins to have an important influence in increasing the friction, so that after a while the curves of μ take reverse turns, and the coefficient attains a minimum value as described above.

As to the positions of the minimum points, we see that the coefficient of friction takes its least value for speeds which depend upon the bearing pressure, those speeds being greater the greater the bearing pressures—Fig. 5.

After the minimum points are passed the curves begin to rise more or less rapidly as the speed continues to fall. This is due to the oil film being squeezed out of the bearing; and we shall find it necessary to attach great importance in the sequel to the so-called "minimum point," as bearings must

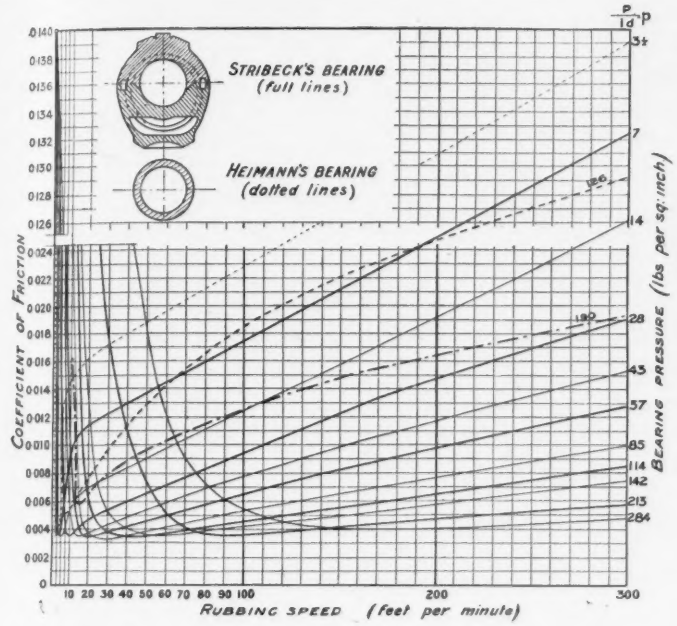


Fig. 5

be designed so as to avoid such speeds and pressures as correspond to them.

In Fig. 6, reproduced from Heimann's article—*loc. cit.*—we observe the effect on the coefficient of friction and on the positions of its minimum points, of an increase of the temperature of the bearing. The higher the temperatures at which the bearing runs the smaller the coefficient of friction, and the greater are the speeds at which the minimum values of that coefficient are attained.

In conclusion, we observe that the curves all rise very rapidly when the speed is very slow and the oil has all been squeezed out of the bearing; and that they tend to converge upon the constant value 0·15, the coefficient of friction for greasy metals sliding upon each other, long ago determined

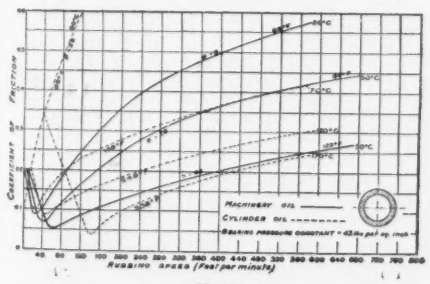


Fig. 6

by Morin. It is only then that μ remains constant, and that we encounter a frictional resistance and loss of work proportional to the load on the bearing and of the amount already calculated.

(*d*) *Formula for coefficient of friction.*—Reverting to the theoretical law of fluid friction mentioned above, viz.:—

$$\mu = \frac{c\,k}{y}\,\frac{v^n}{p}$$

we find that experiments show that n has values diminishing from $\frac{1}{2}$ to 0 as the speeds increase from 100ft. to 3600ft. per minute.

Clearly, the variation should be made in the value of k, the viscosity coefficient, and not in that of v; for the law of shearing resistance is equally kv/y at high as at low temperatures.

If we could calculate the excess of mean temperature of the oil film over that of the metal walls between which it is flowing, then knowing how k depends upon that—mean—temperature we could predict the proper form of the expression for any given case.

The author has found a simple expression which gives the values of k with fair correctness between the temperatures 70 deg. and 160 deg. Fah.; the more correct expression of Osborne Reynolds being—$k = 0{\cdot}000047\,e^{-0{\cdot}0221\,t}$.

* Read before the Manchester Association of Engineers, Saturday, November 23rd. Abstract. †No. I. appeared November 29th.

The formula is

$$k = \frac{B}{(t - 60\text{ deg.})} \text{ or } k = \frac{B}{\theta}, \text{ where B has the value } \frac{1}{500}.$$

Thus we write

$$k = \frac{1}{500\,\theta} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

A roughly accurate expression for the coefficient of friction for machinery oil as deduced from these experiments will therefore be—for speeds over 20ft. per minute—

$$\mu = \frac{C\sqrt{v}}{\theta p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$\mu = \frac{900\sqrt{v}}{500\,\theta\,p} = \frac{1{\cdot}8\sqrt{v}}{\theta\,p} \quad . \quad . \quad (6)$$

Here v = surface speed in feet per minute,
p = bearing pressure in pounds per square inch,
and θ = excess of oil temperature above 60 deg. Fah.

This may be written in the form—

$$M = \mu p = \frac{1{\cdot}8\sqrt{v}}{\theta} \quad . \quad . \quad . \quad . \quad (7)$$

where M may be called the specific friction. It is the frictional resistance per square inch of projected bearing surface.

The quantity $\mu p = M$ is obviously proportional to the frictional resistance or force per square inch of journal area; for the total work spent on friction per minute is $F v = \mu P v = \mu p d l v = M v d l$.

If we divide by $d l$ we obtain ($M v$) the friction work per minute per square inch of projected bearing area; and M is the force of friction per square inch of that area.

A journal starting from cold at a given speed v will warm up until the heat emitted is equal to that generated by friction.

Its temperature will then be

$$\theta f = \cdot 66\,v^{\frac{3}{4}} = \frac{(d\,N)^{\frac{3}{4}}}{4},$$

and its co-ordinates in Fig. 7*a* will be:—

O d, $d\,b$ and $b\,a$, those viz.: of the point a in Fig. 7, which represents its state under finally attained conditions of running.

The rectangle $a\,b\,c\,d$ represents the heat generated per minute per square inch of bearing area; and the line $a\,m$ measures the bearing temperature.

The excess of this temperature over that of the surroundings—60 deg., say—is proportional, according to Newton's law of cooling, to the heat emitted per square inch of bearing area per minute ($e\,\theta$).

If, now, the bearing length were suddenly doubled, the bearing pressure (p) would be halved; but the value of M would—to a first approximation—remain unaltered; for the frictional resistance is quite independent of the pressure in the oil film, being governed only by the rubbing speed—*i.e.*, the diameter and the revolutions per minute—and the temperature of the bearing.

The speed has not altered with the change of length, and the temperature also will not change; for, although the total heat generated in the bearing by friction has doubled, so also has the surface for emitting heat. An alteration in the length will not, therefore, produce any change in the heat generated or dissipated per square inch or in the temperature of the journal.

If running hot before, it will run hot still; we gain nothing from this point of view by lengthening the journal, and, in fact, the total loss by friction will be increased in the exact proportion in which the bearing has been lengthened.

What we get by increased length is a diminished liability to rupture of the oil film—on the "off" side of the point of nearest approach—and to the consequent running of the journal and bearing in metallic contact.

In Figs. 8 and 9 the hollow round spots show the positions of the points of minimum frictional resistance as determined from the experiments of Thurston—*vide* "Friction and Lost Work," 1889, pp. 312 and 314, Stribeck, and Dettmar-Heimann—the latter for a bush, the former two for a half-bearing. These spots indicate that the conditions of running are "critical" for the lubrication of the journal. The oil is just on the verge of being squeezed out. If the journal is to remain a "completely lubricated" one—as Osborne Reynolds named it, the proportions must be so chosen that when the final temperature, due to the given load and speed, has been attained the state-point of the bearing shall lie to the right of the critical point corresponding to the pressure and terminal temperature.

For example:—Let the point a—Fig. 7—represent the final temperature—130 deg. Fah.—of a journal length l_0, dia. d_0, whose rubbing speed is 100ft. per minute; if the pressure per square inch of bearing area (p_0) be such under the given load P that a is also the squeezing-out or critical point at 130 deg., we shall be liable to have a hot journal. Suppose now that the length is increased from l_0 to l_1, until the pressure falls to p_1—26 lb.—per square inch. Then, as explained above, a will still represent the journal's state point; but the critical point will have moved away to the left to e. The load could be increased now from $P_1 = p_1 d_0 l_1$ to $P_2 = p_0 d_0 l_1$ without fear of the journal running dry. The ratio of P_2 to P_1 may therefore be called the factor of safety of the journal when its proportion has been altered as indicated.

If, on the other hand, we increase the diameter from d_0 to d_2 by the same amount as we formerly increased the length so that the pressure p_0 is diminished, as before, to p_1—26—then the frictional resistance will increase—because the speed increases with the diameter. The point f will at first represent the state. The frictional work turned into heat by the journal will, however, be increased much more than the area of the heat-emitting surface for dissipating it. Therefore the bearing temperature will rise, and some such point as g on a higher temperature curve—here 190 deg.—will be the final state-point. The heat generated per square inch of bearing is now represented by rectangle $g\,h\,k\,i$, which is clearly greater than $a\,b\,d\,c$.

Now the bearing pressure is again equal to p_1 (26 lb. per square inch); therefore, the critical point at the new temperature—190 deg.—for this pressure is shown by point l on the same vertical plane through O as contained e. The factor of safety is apparently greater than was obtained by lengthening the diameter; but this superior security has been attained only at the expense of a much larger frictional loss. The exact values in an example are worked out in the sequel.

In most cases the diameter is fixed beforehand by considerations of strength or stiffness, and the only way of getting a factor of safety is to diminish the bearing pressure by increasing the length.

In endeavouring to apply the theoretical explanations and experimentally derived formulæ discussed by the author to the design of a bearing, what we want to know is—What is the proper proportion of length to diameter under any given conditions as to load, speed, and mode of lubrication; having regard also to the fact that the requirements demanded from the point of view of strength and stiffness must also be met.

Expressed in words, the author's formulæ mean that the steady or finally attained temperature of a bearing of given diameter is higher the greater the three-quarter power of the revolutions, and is greater for a given speed the larger the three-quarter power of the diameter. It is, however, quite independent of the length of the journal.

We cannot, therefore, hope to lower the terminal temperature by lengthening the bearing. The heat generated increases as fast as area for dissipating it does; for although by lengthening the journal the bearing pressure is diminished, yet since μ varies inversely as p, the frictional resistance and the heat generated are *pari passu* increased.

We know, however, from experience, that journals must be made long for high speeds, and the above conclusion seems at first sight to conflict not only with the text-books, but also with practice, and so to be paradoxical.

The explanation is as follows:—Whilst it is true that the final temperature to which a bearing will rise after a long run under a given load and with a given lubricant, depends only on the diameter of the spindle and on the speed of revolution, *i.e.*, only on the rubbing velocity, and not at all upon the length of the journal, we have to remember that if that finally attained temperature be too high the lubricant will be squeezed out unless the bearing pressure is low.

The authors, having discussed various formulæ, prefer to

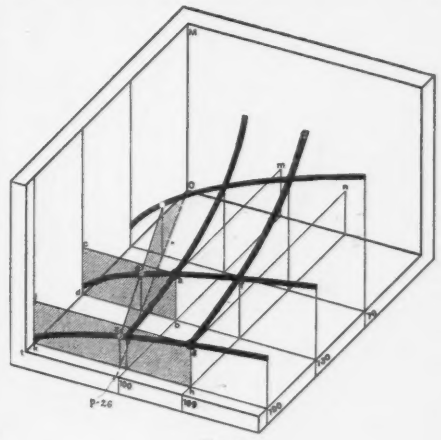


Fig. 7

use, in designing bearings, the expression $v_0 = C\,p\,\theta$, with $C = \frac{1}{15}$ for the value of the constant; and when written in the form

$$\theta_c = \frac{40\,v_0}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

we see that it gives the critical value (θ_c) of the rise of temperature, above which, under the given conditions as to surface speed (v_0 ft. per minute), and bearing pressure (p lb. per square inch), the oil will be in danger of leaving the bearing and allowing it to run with metallic contact of the rubbing surfaces.

What we are now proposing then is to fix the proportions of journals by reference to the minimum points of the experimental friction curves already discussed, assuming them to indicate the critical conditions as regards speed, pressure, and temperature of the bearing, below which it is unsafe to run.

We first calculate the terminal rise of temperature of the bearing by the expression $\theta_f = \frac{(d\,N)^{\frac{3}{4}}}{4}$. We then equate this to the value $\theta_c = \frac{40\,v}{p}$ of the above critical temperature, and so obtain a relation between the length, the load, the diameter, and the speed of revolution.

We thus have

$$\frac{(d\,N)^{\frac{3}{4}}}{4} = \frac{40\,v}{p}$$

Substituting $\frac{\pi d N}{12}$ for v, and $\frac{P}{l\,d}$ for p, we may write this

$$\frac{(d\,N)^{\frac{3}{4}}}{4} = \frac{40\,\pi\,d^2\,N\,l}{12\,P},$$

from which we obtain

$$l = \frac{P}{40\,d^{\frac{5}{4}}\,N^{\frac{1}{4}}} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

This is the formula proposed for use in the design of journals for speeds of rubbing up to about 450ft. per minute.

It has been found to agree well with practice in all the different examples on which it has been tested.

In those cases in which it does not agree, it is to be surmised that the practitioner has been misled by adherence to the erroneous theory alluded to above.

As an example of the use of the formula we may take the case of self-oiling bearings for line shafting.

For ring-oiled bearings or other cases in which an abundant supply of lubricant can always be maintained between journal and brass we proceed in the following manner :—

The critical temperature of the bearing expressed as an excess above 60 deg. Fah. is:—$\theta_c = \frac{40\,v_o}{p}$; v_o being the speed (ft./min.) at which metallic contact is in danger of occurring under the given bearing pressure p (lb./sq. in.).

The finally attained temperature of the bearing of diameter d (inches) [after running, *i.e.*, for several hours] at the speed of revolution N (revs./min.) is (also in excess of 60 deg. Fah.)

$$\theta_f = (d\,N)^{\frac{3}{4}}/4.$$

For cool running, without wear, we must therefore have θ less than, or, at most, equal to, θ_c, *i.e.*, $\frac{(d\,N)^{\frac{3}{4}}}{4} < \frac{40\,v_o}{P}$

Now, if l is the (unknown) length of the bearing and P its given load, we have $p = \frac{P}{l\,d}$. Also, if the final temperature attained is allowed to be just over the critical temperature corresponding to the given speed and load: then $v_o = \frac{\pi\,d\,N}{12}$.

So that we have—

$$\frac{(d\,N)^{\frac{3}{4}}}{4} = \frac{40\,\pi\,d^2\,N\,l}{12\,P}$$

or—

$$l = \frac{P}{40\,N^{\frac{1}{4}}\,d^{\frac{5}{4}}}.$$

The values of $p = \frac{P}{l\,d} = 40\,N^{\frac{1}{4}}$, for the various cases usually occurring in practice (that is for ordinary values of d and N) have been calculated. They are shown as curves in the annexed Fig 10.

Thus, if we have a shaft 2in. diameter running at 100 revolutions per minute, the bearing pressure, which must not be exceeded if a complete film is always to be maintained, is by the diagram 150 lb. per square inch. Hence, if the load (P) were 600 lb., the length of the journal would be

$$l = \frac{P}{150\,d} = \frac{600}{150\,d} = \frac{4}{d} = 2\text{in.}$$

If the load were 1200 lb., the journal would have to be 4in. long, and so on.

With the same diameter of shaft, if the speed were only 25 revolutions, the bearing pressure allowed would be reduced to about 100 lb.; and the length would be

$$l = \frac{P}{100\,d} = \frac{600}{100\,d} = \frac{6}{d} = 3\text{in. for a 600 lb. load.}$$

If, on the other hand, the speed were 500 revs./min., the bearing pressure might be as high as 225 lb., and the length need only be $l = \frac{600}{225\,d} = 1\frac{3}{4}\text{in.}$

In other words, the allowable bearing pressure $p = \frac{P}{l\,d}$ varies between 100 lb. and 225 lb. per square inch, according to the expression, for the different speeds and diameters above indicated.

It will be noticed that, contrary to the view usually accepted, the length must be greater the slower the speed.

This is clearly correct; for the slower the speed the greater difficulty has the journal in dragging in its supply of oil to meet the required demand in opposition to the bearing pressure which is squeezing it out.

The lower must that bearing pressure accordingly be; *i.e.*, the greater l for a given d, in order to enable the journal to maintain its oil film unbroken.

(*f*) *Journals for heavy loads at low speeds.*—Another set of conditions which are frequently met and have to be dealt with in practice are those in which a journal has to run under a heavy load at a very slow speed.

A very commonly occurring case is that of an ordinary lathe spindle when taking its deepest cut or carrying its heaviest load at its slowest velocity of rotation.

It may fairly be assumed that every lathe will at times be called upon to take a finishing cut at a speed of 18ft. per minute upon a heavy job of face-plate diameter of the greatest length the lathe can take in, and of which one-third the weight will be taken by the front journal. We obtain, therefore, the following value of load and speed (h = height of centres) :—

The weight of the job assumed, $2\,h$ in diameter and $6\,h$ long, is

$$\frac{\pi}{4}(2\,h)^2 \times 6\,h \times 0{\cdot}3\,\text{lb.} = 5{\cdot}66\,h^3\,\text{lb.}$$

One-third of this will be $2\,h^3$ (and allowing for the weight of face-plate, &c), or $W = 2\,h^3$.

If the bearing be taken of diameter $\frac{h}{3}$, the rubbing speed is $\frac{18 \times h}{3 \times 2\,h} = 3\text{ft. per minute}$; and, according to the above table, the safe load is therefore from 6 lb. to 48 lb. per square inch of projected bearing area. But the actual bearing pressure will be, if we assume the usual value $\frac{h}{2}$ for the length of the journal,

$$p = \frac{2\,h^3}{\frac{h}{2} \times \frac{h}{3}} = \frac{12\,h^3}{h^2} = 12\,h\text{; i.e., 120 lb./sq. in.}$$

for a 10in., and 600 lb./sq. in. for a 50in. lathe.

We see, therefore, that it is impossible to give the large dimensions to the front bearing that would be necessary to prevent the oil film from being broken at such low speeds; and, as a matter of fact, lathe spindles turning at the slow speeds used for heavy cuts inevitably run metal-to-metal with their brasses, giving rise to the high frictional resistance corresponding to the coefficient of friction of 0·15 for greasy metals.

The work thus spent and wasted on friction and wear may, as worked out above, amount from 2 per cent to 10 per cent. of the total useful work expended on cutting. From ¼ to 9—according to size—horse-power is, therefore, wasted on the friction of the front journal alone when the lathe is running at these slow rates with a heavy job between centres.

By using a force pump, however, and injecting a stream of moderately heavy oil into the bearing at the place where the pressure is greatest, it is possible to raise the journal off the brass even when at rest, and to keep it floating with a film of oil interposed between itself and the bearing when in motion, much more resistance to motion at high speeds than does a lubricant of low viscosity, the much greater thickness of the plastic film, when the speed is low, makes the static friction less than is given by most, if not all, truly viscous fluids. On this account, although the friction of a rapidly moving train lubricated by oil may be much less than when plastic greases are used, a much greater force is required to set the coaches in motion. Greases have consequently maintained their position as lubricants for low-speed goods trains on most lines. To keep the rubbing surfaces of bearings from coming in contact, owing to the expulsion of the lubricant by the load, when their relative velocities are small, oils, waxes, and greases containing solid lubricants are much more extensively used than are solids alone.

"The viscous or plastic matrix acts as a carrier for the solid lubricant, enabling it to be more readily applied to the rubbing surface. Should the liquid lubricant be rubbed out, the heating arising from the increased friction melts the matrix, and the mixture containing the solid immediately runs on to the dry surface. Such compounds are for heavy pressures and low speeds. At high speeds their frictional coefficient is very great, and the heating and loss of power is proportionately serious. Their use is therefore restricted to bearings which are only in motion occasionally, such as the journals of tip wagons, or the axles and spindles of hauling machinery."

In order to be in a position to design a bearing correctly and with the same exactitude as we find the proportions of a piston-rod, or any other working part of a steam engine, for strength and stiffness, we see that the nature, viscosity, and laws of the critical pressure of the lubricant which is to be used must be known or assumed beforehand.

The determination of the "critical" or of minimum friction point is, in fact, the most important physical datum required to be known. Very few experimenters have paid any attention to it, and those who have done so seem not to have noticed its high significance as a means of fixing the proper proportions of journals to meet any given conditions

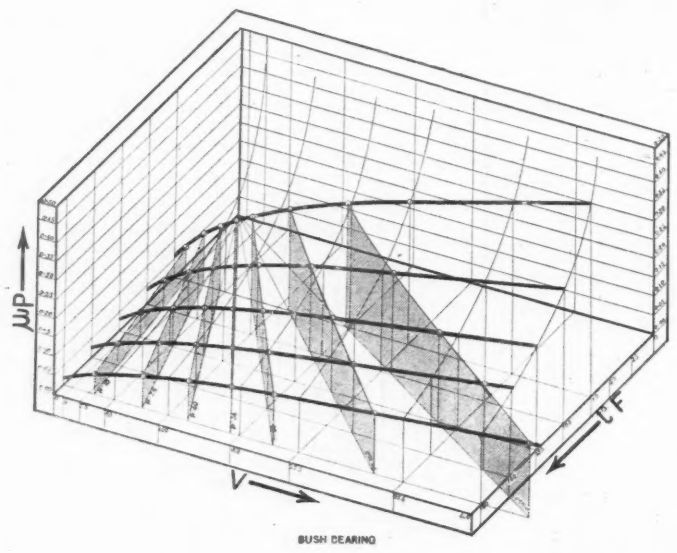


Fig. 8

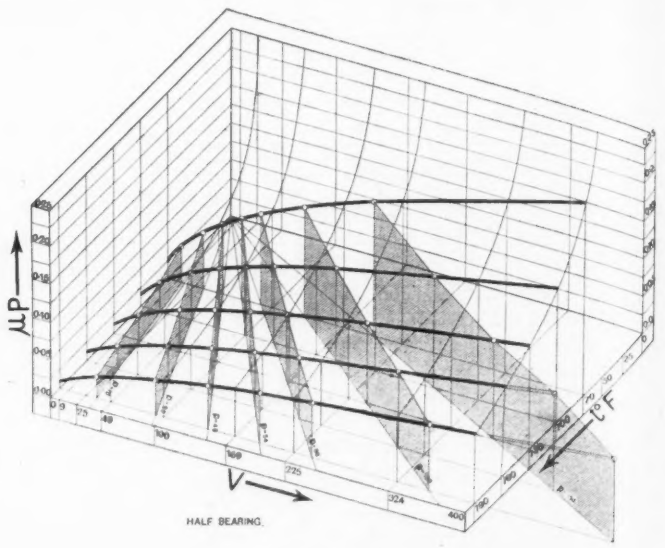


Fig. 9

be that motion as slow and the load as high as it may.

If metal-to-metal contact can in this way be prevented at slow, and by the ordinary methods at high, speeds, there seems to be a possibility that wear may be entirely eliminated.

The remedy usually employed in practice to lessen the friction and wear for heavy loads at slow speeds is to employ either a more viscous lubricant, such as castor oil or grease, or a mixture of a fatty and a mineral oil. The effect of this is clear if we glance at Heimann's curves on Fig. 6. The dotted curves there shown are for cylinder oil, and the greatly diminished value of the rubbing speed for the critical point at any given temperature shows how much

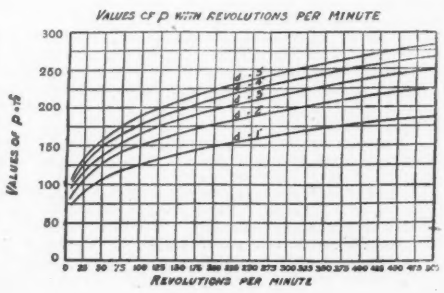


Fig. 10

more slowly we are enabled to run without fear of rupturing the oil film, if we make use of a thicker oil.

The following quotation from Messrs. Archbutt and Deeley's standard work on "Lubrication and Lubricants," page 63, bears upon this point and has special reference to railway journals:—"For a number of years 'greases' were almost exclusively used for railway axles. They are generally emulsions of water, tallow, and some vegetable oil, with sufficient alkali to neutralise the acids and form soaps. Such axle greases require a definite pressure to cause them to flow, and cannot be completely squeezed out from between the brass and its bearing. They are, on the other hand, readily forced in at the higher velocities. Although offering of speed, load, and method of lubrication. It is to be hoped that in future experimental work will be extended so as to cover this determination for all the ordinary varieties of lubricating material used in practice.

CONGRESS ON NAVIGATION.

THE Eleventh International Congress of Navigation will take place at St. Petersburg from the 31st of May to the 7th of June next, under the patronage of the Emperor of Russia. The scope of the questions usually taken under consideration at these congresses has been enlarged by introducing into the second section "The Industrial and Agricultural Utilisation of Rivers." The programme of the forthcoming Congress includes the following subjects :—

INLAND NAVIGATION.

Arrangements to be made for weirs in rivers having great variations of discharge and carrying large quantities of ice, so as to subserve the interests of navigation and industry.

Economic, technical, and legislative study of the exploitation and mechanical traction of boats and rivers, canals and lakes.

Fitting up of ports for inland navigation, and in particular the progress of electric equipment.

Mixed canals that can serve both for navigation and for agriculture.

Protection of low-lying regions against flooding.

Application of armoured concrete to hydraulic constructions.

Methods of co-operation on the part of the Government with such as are interested in the measures to be taken for the development of inland navigation.

Hydrometry, reporting the rising of the water, and the breaking up of the ice.

MARITIME NAVIGATION.

Fishing ports and harbours of refuge for coasting vessels.

Inland sea ports and their means of approach.

Construction of harbours on sandy beach.

General conditions of the security of maritime navigation.

Hydrographic exploration of the seas.

Repairing appliances, including dry docks, floating docks, and lifting apparatus.

Types of sea-going vessels in relation to inland harbours and waterways.

Application of armoured concrete to sea works.

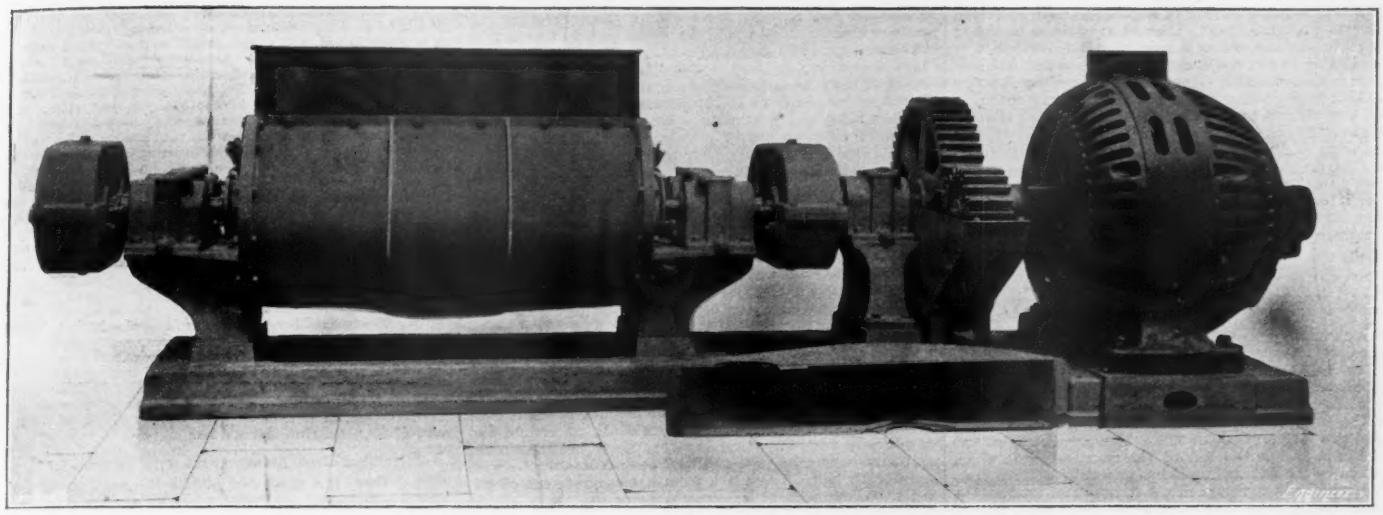
Reports on most recent works carried out in the principal sea ports.

Scientific excursions will be arranged for an inspection of some of the rivers and seaports of Russia.

The address of the General Secretary of the Congress is 7, Ismailovsky Prospect, St. Petersburg.

ELECTRICALLY DRIVEN HIGH-PRESSURE BLOWER

SAMUELSON AND CO., LIMITED, BANBURY, ENGINEERS



HIGH PRESSURE BLOWERS.

AT the invitation of Samuelson and Co., Limited, we recently visited their works at Banbury, for the purpose of inspecting their high-pressure blowers. For many years, we understand, blowers of the Roots type have constituted one of this firm's chief products, and a very large number of them has been made. Some of the blowers which were going through the shops at the time of our visit were notable for their large outputs; others were very small, such, for example, as those to be used in connection with oil gas lighting, and for blowing small fires. In some cases the blowers were to be operated by hand, others were being fitted with pulleys, and there were also several steam-driven blowers running, and a number in the course of manufacture.

The principle of the Roots blower is so well known that it is unnecessary to deal with it here; on the other hand, however, the particulars concerning their mechanical construction and the special features which were explained to us are worthy of mention.

The revolvers of these blowers are of cast iron, and they are each cast in one piece. Before any machining is done to the surfaces of these revolvers, they are forced on to the carbon steel spindle by hydraulic pressure, and they are afterwards keyed. The spindle is then turned and ground, after which they are set up in the planing machine on the finished spindle and the outside surfaces machined to a gauge, when the shape of the revolvers is taken into consideration, and the small amount of clearance which is necessary between them and the blower casing to ensure satisfactory operation; this method of procedure appears to be a good one. The interior of the blower casing is, of course, machined all over, so as to obtain the minimum amount of clearance between the casing and the revolving parts. During our visit the clearance was tested on one of the blowers which had just been shut down, when it was found that a feeler-gauge having a thickness of twelve thousandths of an inch would not enter between the revolvers and the casing at any part. Before erection the revolvers are statically balanced on knife edges.

The bearings are of phosphor bronze, having a length from three and a-half to four times the diameter of the shaft. By giving the bearings ample length we understand it has been found quite unnecessary to use a bearing outside the pulley or engine. The bearings are turned to a taper on the outide, and they are split on the top in a direction parallel with the shaft, so that in the event of wear taking place, the shaft can easily be brought up central by gently screwing the bearings into the coned plummer block, by means of set screws which are provided for that purpose. The bearings are lubricated by means of oil rings. The gear wheels which couple the two revolvers together are machine cut, and they are totally enclosed in an iron gear box, the latter containing oil in which the gear wheels run. Another feature in connection with these blowers is that the glands are packed in a special manner. While the clearance between the sides of the revolvers and the blower casing is insufficient to allow much air to leak when the blower is working at medium pressures, it has been found advisable, in view of the fact that the blowers can work up to as much as 10 lb. to the square inch, to provide a means of packing the glands, which takes the form of an ingeniously devised metallic packing ring.

A blower which was being driven from the shafting at about half its maximum speed, namely, about 150 revolutions per minute, gave a pressure of fully 5 lb. to the square inch on a mercury gauge, and delivered 15 cubic feet of air per revolution. The efficiency of this blower, we understand, when working under these conditions had been found to be 80 per cent., and we were told that at full speed a substantial increase over this efficiency could be obtained.

Among the steam-driven blowers there was one of the duplex type, designed for being driven by a high-pressure steam engine which was compound, and was fitted with piston valves. The engine was provided with two connecting-rods, each rod driving a separate revolver in the blower. In the latest type of steam-driven blower manufactured by the firm, however, the engine, whether simple or compound, has only one connecting-rod, which is coupled to a disc crank on one of the revolver shafts, the other revolver receiving its power entirely through the gear wheels. This latest arrangement, we were told, has proved to be quite successful, but in view of the fact that some engineers favour the duplex rod engine, it has been decided not to discard the old designs. Another engine coupled to a blower was designed for medium pressure steam; this engine was of the simple type, and was provided with the ordinary D valve. In some instances the engines are fitted with a hand-operated adjustable cut-off, and they are constructed for superheated steam when necessary.

An electrically driven blower is shown above. In cases of this description the motor is frequently designed for a wide speed variation, which is obviously an essential feature, when the duty required of the blower is of a variable character. The chief feature of this plant is the small amount of space which it occupies, particularly as regards head room. Several blowers, we were told, have recently been erected for the Tropenas process of steel making.

Some little time ago the firm took up the manufacture of high-lift pumps constructed on the same principle as the blowers, and before leaving we had an opportunity of seeing one of these pumps.

A SMALL ELECTRICITY PLANT.

An attractive exhibit at the Motor Car Exhibition, which was recently held at Olympia, was a small generative system

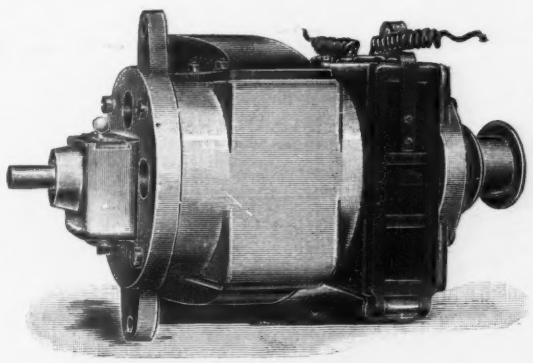


Fig. 1—ELECTRIC GENERATOR

designed and made by the Electric Ignition Company, Limited, of Sparkbrook, Birmingham. It is intended to provide a complete lighting and ignition system for motor vehicles of all types, and is claimed by the makers to be more trustworthy than the ordinary magneto. The generator—which we illustrate in Fig. 1—is compound wound, so that the output is always kept constant, and should any sudden acceleration of the engine occur, no excess current is generated, the latter always remaining constant. It is fixed

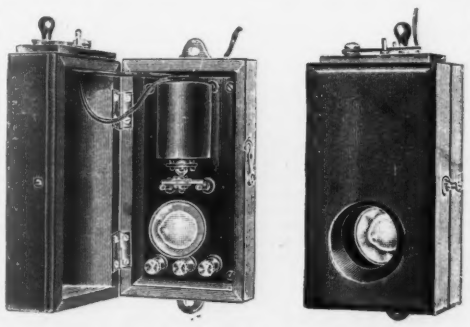
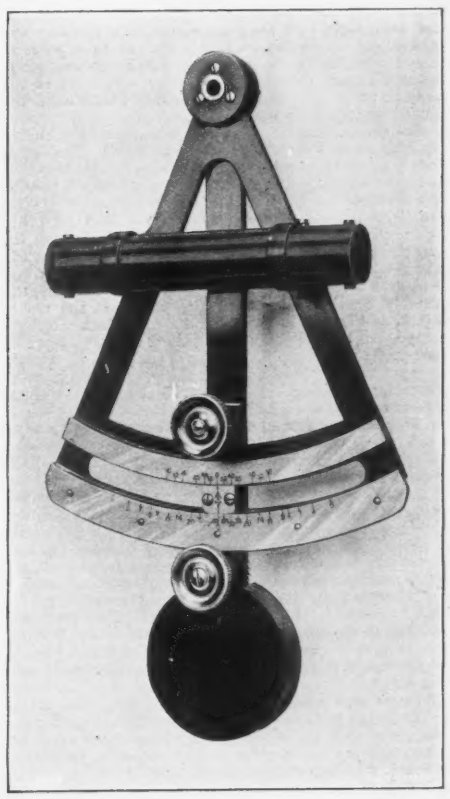


Fig. 2—CUT-OUT AND TELL-TALE LAMP

to the car similarly to the magneto, and can be driven in any suitable manner. The makers recommend a belt drive in preference to any other, and state that the gear ratios should be such that the generator makes 1000 revolutions per minute to 700 of the engine shaft. It gives about 4 amperes at from 8 to 12 volts, and enables two 4-volt accumulators to be charged in series, which are used both for ignition purposes, and in series at 8 volts for lighting. In conjunction with the generator, the makers supply a patented cut-out—an illustration of which is shown in the engraving Fig. 2—which cuts out the generator when the speed of the armature falls below 400 to 500 revolutions per minute, equivalent to a car speed of eight to ten miles per hour. Special accumulators which are so constructed as not to be affected by overcharging are made by the firm. The generator, besides charging the accumulators, also supplies sufficient current for lighting the side lamps and rear lamp of the car, and also the internal lamps in the case of landaulette and limousine bodies. In connection with the tail lamp, the company fits a small tell-tale lamp—Fig. 2—which is attached to the dashboard in front of the driver, and should the rear light be extinguished for any reason, the lamp on the dashboard also goes out.

A NEW ROAD TRACER.

THE accompanying engraving illustrates a road tracer which is claimed to be an improvement on the well-known Ghat-tracer, which is so largely used in India and our Colonies. It has been made by Messrs. W. F. Stanley and



ROAD TRACER

Co., Limited, of High Holborn, W.C., from the designs of Mr. C. V. Bellamy, M. Inst. C.E., who is Director of Public Works in Lagos, West Africa. It is intended for use in preliminary survey work, the tracing and construction of roads, and other similar undertaking. In the instruments mostly in use for such work there is usually a straight scale along which a weight is moved by means of a screw. The chief improvement claimed for Mr. Bellamy's instrument lies in the adoption of the arc of a circle and a weighted pendulum instead of the straight scale and sliding weight. The pendulum is suspended at the same centre as the arc, and is moved to any position along the arc by means of a

rack and pinion actuated by a milled head. A clamp is provided for locking the telescope at any desired gradient. The pendulum carries an index which reads to the divisions upon the arc.

The sighting tube is fixed to the frame which carries the arc, and is at right angles to the pendulum when its index is reading zero. In this position it, of course, sights horizontally. Instead of being marked in angles, the scale is divided so as to read gradients direct. The sighting tube is furnished with adjusting screws, so that it may be adjusted should it be deranged owing to any rough usage it may receive. The eyepieces are made reversible, being fitted with sliding shutters to enable a back reading to be taken by merely changing the shutters without unclamping the instrument or altering the index. The instrument is carried on a staff on which a steel fulcrum is fixed, and a special target is also included in the equipment. It is strongly made in gun-metal, and there are no delicate pieces of mechanism which can get out of order if ordinary care is exercised. If we may suggest what we consider would be an improvement, it is that longer sighting tubes be fitted if desired.

BLACKFRIARS BRIDGE ACCIDENT.

In his summing-up at the inquest in the City Coroner's Court, on the 18th inst., on the accident at the Blackfriars Bridge works, Dr. Waldo, after having referred in general terms to the accident, proceeded to describe the actual methods adopted by the contractors. In order, he said, to widen the bridge the piers on the west side were being extended to a length of about 30ft. The foundation of the pier had to be laid in the bed of the river, access to which was gained by the sinking of caissons or water-tight compartments in which the workmen might descend and conduct the operations beneath the surface of the water. Each caisson weighed some 230 tons, and was lowered to the bed of the river from a staging of piles. The sides of the staging were connected at the top by two sets of transverse girders running north and south. At each of the four corners of the staging a powerful jack rested upon the cross girders. The jacks were not fastened to the girders but were kept in position by their own weight. Piercing each jack was a powerful steel rod or "link," attached by its lower end to the caisson. The links were connected with the jacks by steel pins or cotters. The jacks were set in action by hydraulic pressure, and they simultaneously, by means of the four links, raised the caisson a fraction of an inch, so as to ease the cotters or pins. The pins were then knocked out of position and fixed in other slots 13in. higher up the link. The water was then run gradually out of the jack, and the pressure being reduced the link and caisson descended some 13in. Each jack was worked by a single man under the direction of a foreman, who gave the order to pump up, and later to lower. The pumping up was done by a hand pump in charge of the same man, who during that process turned the tap connecting the pump with the jack into a certain position to admit the water to the jack. When this was completed he turned the handle of the tap vertically upwards, in which position the water compartment of the jack was closed. When the order to lower was given, the man at the jack moved the handle into a horizontal position, the reverse of that which he took in admitting water to the jack. From this description, he added, it would be seen that the caisson hung suspended by the links, and the weight was thereby thrown on the jacks, to which the links were indirectly attached by the cotters. From the jacks the weight was transferred to the girders. It was clear, then, that the great weight of the caisson was distributed equally among the four jacks, and to be properly sustained must demand the integrity of links, cotters, jacks, girders and staging generally. In the present instance the primary cause of the accident appeared to have lain in the defective working of the jacks.

In the process of lowering the caisson the weight should be distributed evenly between the four jacks. The centre of gravity is, or should be, kept somewhere near the centre point of the caisson. Should the jacks not lift or lower the caisson simultaneously, it is clear that the centre of gravity will be disturbed and the caisson be tilted in one or other direction. The essence of the whole process of lowering the caisson lies in the simultaneous action of the jacks. The men in actual charge of the pumps and jacks are clearly best able to give evidence on this point; two of them are, unfortunately, dead, namely, Forster, in charge of the north-west jack, and Grant, in charge of the south-east. In both these instances, however, other evidence was forthcoming which showed pretty conclusively the state of the jacks in relation to their actual position as regards raising or lowering at the moment of the accident. Buchanan, in charge of the south-west jack, states that he had not heard any order given to lower, and had not turned the tap to exhaust, so that we may safely conclude that the caisson was not then lowered at the south-west corner. Grant, who was in charge of the south-eastern jack, was drowned; but we have the evidence of Buchanan and others that the tap under his charge was practically turned off, so that we may infer the caisson was not lowered at the south-east corner. Turning to the north-east corner, we have the statement of Neilson that in obedience to the order of Irvine he had turned off the exhaust, and the jack was practically emptied at the time of the accident. This was proved by the finding of the tap afterwards turned in the exhaust position. This statement shows that at the north-east corner the caisson was lowered. Lastly, turning to the north-west jack, we find that Forster, the man in charge, died on the way to hospital shortly after the accident. There is independent evidence, however, which shows with tolerable certainty what took place at that jack. It should be explained here that the usual hand pump on the girder used up to ten o'clock of the morning of the accident, had got out of order and was replaced by a larger pump worked by two men on the deck jetty below. These two men, Reid and Williams, state that in obedience to an order from Irvine they pumped up, thereby filling the jack and raising the caisson. A little later the water trickled down from the exhaust pipe, and in order to avoid getting wet they moved in different directions.

This evidence seems to show conclusively that the jack was emptied at that moment, and therefore the caisson was lowered at the south-west jack. Later the jack was fished up from the bottom of the river, but its tap was found in its original position at the top of the staging still attached to the copper filling pipe which ran up from the pump on the deck below. It is suggested by all the expert witnesses that this tap must have been severed before the accident, presumably by the fall of some heavy object, such as a hammer or spanner. This theory is supported by the fact that the piping is uninjured, whereas had it fallen while still in connection with the jack, it would have been indented and bruised, as happened in the case of the three other pipes. Sir Alexander Binnie is emphatic on this point. The unavoidable inference is that the tap was broken off before the time of the collapse.

So far, then, we may absolutely conclude that at the moment of the collapse the southern jacks were full and northern empty. This would throw the centre of gravity of the caisson out of its normal position, and this again would cause the caisson to sway to one side. Without going into details it may be said that the subsequent train of events was somewhat as follows:—The girders next the bridge turned on their sides and bent with a long downward curve from the south side, ending in a shorter upward curve at the north. This was actually seen to take place by Hankins, who was standing on the bridge talking to the foreman Peacock.

"As regards this point of the inquiry," continued Dr. Waldo, "I think, gentlemen, we may safely accept the theory of the engineers, that the fall of the caisson was due to want of uniform action between the four jacks. The jack mainly at fault was the north-western, and if we accept the expert opinion there was probably some injury to the tap, causing the emptying of the jack and the consequent lowering of the caisson at that particular point in advance of the other jacks, which had not yet commenced to lower, except possibly the north-eastern jack to a partial extent. There is no evidence to show that there was any flaw or structural defect in any part of the staging or appliances except in the north-eastern jack, which appears to have been damaged immediately prior to the accident. It should also be carefully borne in mind that the same jacks and other appliances were used in the three other caissons which were successfully laid. There is a remarkable agreement of evidence on the part of the experts as to the cause of the disaster. On the other hand, there are no material points of disagreement. "Under these circumstances," concluded the Coroner, "I think the jury will have little difficulty in arriving at a verdict of death due to accidental causes." Dr. Waldo then made some remarks with regard to the avoidance of similar accidents in the future.

The unanimous verdict of the jury was that the disaster was purely accidental, and was not due to the neglect of any precautions regarding the structure or in the working of the necessary plant used in the widening of the bridge, and that the appliances were, in their opinion, especially as regards the jacks and girders, the best that the existing state of engineering science could provide, under circumstances both of ordinary and of extraordinary strain, and that the system of simultaneous control of the jacks in lowering and raising the caisson was reasonably perfect. The jury also suggested that in future the cocks should be visible to the men working the jacks and not be covered with sacking, and they agreed with the Coroner's suggestion that the cocks in future should be protected by a shield from above. They further recommended, for the future, that each pair of girders be "box girders."

At a meeting of the Hanley Watch Committee recently held at Hanley attention was drawn to the unsatisfactory condition of the water supply in the higher parts of the borough, which, it was stated, would suffer severely in the event of a serious outbreak of fire. As this serious matter has frequently been discussed by the committee, it was decided to appoint a deputation to interview the engineer of the Staffordshire Potteries Waterworks Company on the subject, with the view of obtaining an increased pressure in the mains.

The West of Scotland Iron and Steel Institute.—This society has forwarded to us the following notice:—(1) One of the objects of the Institute is to encourage the contribution of original papers, dealing with any matters concerning the iron and steel industries. (2) It is recognised that the value of a communication is not measured either by its length or by the wide ground which is covered. The most valuable and important are often those dealing with small details, and in short communications. (3) With a view of encouraging communications of value and interest, the society proposes to offer three awards, the first, value £15; the second, value £10; and the third, value £5, on the following conditions:—(4) The competition is open to everybody connected with either the technical or theoretical practice of any industry connected with the manufacture of iron and steel, and embraces those branches connected with the ore products—*i.e.*, apart from coal—up to and including the finished material. (5) The Council will not make awards unless communications of adequate merit are received. (6) It may give more than one premium in the same subject, if there should be several deserving memoirs on such subject. (7) In the adjudication of the premiums no distinction will be made between communications received from members of the Institute or strangers, whether natives of Great Britain or not. (8) The quality and merits of the papers will be judged in relation to the age of the competitors, a division being made of those below twenty-five years of age, and those above. (9) In these communications, the use of the first person should be avoided. They should be legibly written on foolscap paper, on one side only, leaving a margin on the left side, in order that the sheets may be bound. Every paper must be prefaced by an abstract of its contents not exceeding 1500 words in length. (10) The papers shall be signed with a *nom de plume*, the name of the writer being attached in a sealed envelope. (11) Illustrations should be drawn on drawing or tracing paper, and figured dimensions should be introduced only where necessary. When an illustrated communication is accepted for reading a series of diagrams or lantern slides will be required, so drawn and coloured as to be clearly visible at a distance of 60ft. These diagrams will be returned. (12) Papers which have been read at the meetings of other societies, or have been published, will not be accepted. According to the by-laws, every paper presented to the Institute is deemed to be its property, and may not be published without the consent of the Council. (13) Every paper, map, plan, drawing, or model presented to the Institute shall be considered the property thereof, unless there shall be some previous arrangement to the contrary, and the Council may use the same in any way and at any time they think proper. Should the Council refuse or delay the publication of such paper beyond twelve months from the time of the award, the author thereof shall have a right to copy the same, and to publish it as he may think fit, having previously given notice in writing to the Secretary of his intention. Except as hereinbefore provided, no person shall publish, or give his consent for the publication of any communication presented to and belonging to the Institute, without the previous consent of the Council. (14) The sole rights of making the awards and judgment shall rest with the Council of the West of Scotland Iron and Steel Institute, against which there shall be no appeal, and whose judgment shall be final. The awards shall be made by 31st October, 1908. (15) While not necessary, it is desirable that parties intending to send in a communication shall advise the Secretary not later than 31st January, 1908, and the papers should be in his hands not later than 31st August, 1908. (16) Papers contributed by members of the Council will not be eligible for awards. (17) Premiums will be given in kind, not in cash, except in special circumstances.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Raw Iron Market.

The small amount of business passing in pig iron affords little light on the question of prices. Generally speaking, there is no pressure to sell, but where special reasons operate sellers can only do business by making substantial concessions. Current quotations of the most remarkable sellers remain at 55s. for Staffordshire common forge, 57s. to 58s. for part-mine, 54s. to 55s. for Northamptonshire, and 56s. to 57s. for Derbyshire. Other sellers quote Staffordshire cold blast, £5 15s. and £6; best hot air, 87s. 6d.; part-mine, 61s. 6d. and 62s. 6d.; common, 56s. and 57s.; Derbyshire, 57s. 6d. and 58s. 6d.; ditto foundry, 61s.; Northampton, 55s. 6d. to 57s. 6d. Some of the South Staffordshire brands are not quite so strong as of late. In certain directions it is said substantial concessions are being made by makers, whose order books are being exhausted. But such concessions seem to be restricted to the commonest iron. Some smelters are still sufficiently well off for orders to refuse anything but small reductions. Customers who have sufficient raw iron for December will not take further deliveries until the new quarter opens.

Manufactured Iron.

The marked bar trade seems fairly steady, but for other descriptions of bars there is only a very cramped market. Marked bars remain at £9, North Staffordshire crown bars at £7 10s., and South Staffordshire common bars £7 2s. 6d. and upwards. Other descriptions of manufactured iron are quoted:—Sheets, singles, £8 to £3 5s.; doubles, £8 2s. 6d. to £8 7s. 6d.; trebles, £8 15s. to £9; hoop iron, £7 15s.; gas strip, £7 10s. to £7 12s. 6d.; slit nail rods, £8 10s.; and rivet iron, £7 15s.

Galvanised Sheet Arrangement with America.

There is a great deal of talk this week concerning an alleged arrangement between the English makers of galvanised sheets and the American makers touching the threatened competition of the United States makers with British galvanised sheets in the South American markets. At the recent meeting of the British Makers' Association it is known that Mr. Farrell, of the United States Steel Corporation, was present, and a report is current that this gentleman induced the British makers to accept terms satisfactory to the American producers. The report is not yet authenticated, but a good deal of credence is given to it. Anyhow, the decision of the English Makers' Association as to immediate prices was to retain the minimum selling basis hitherto ruling of £13 2s. 6d. for 24 gauge f.o.b. Recent demands have doubtless been coming in less freely, taking the galvanised sheet trade as a whole, but the maintenance of the standard minimum price tends to show that the position of makers is still fairly satisfactory. Some leading works are understood to be well booked ahead.

British and American Wire Rod Trade.

Rumours as to various international developments are plentiful. One rumour has to do with a supposed combination between America and Germany to flood the United Kingdom with wire rods for rolling down into finished wire. A certain audacious plan for partitioning the British markets is circumstantially described. The only basis of fact discoverable, however, at the moment is an undoubted offer by a large Pittsburgh firm to supply small steel wire rods at £5 17s. 6d. The price seems incredibly low, and certain merchants are strongly disposed to accept it. It represents a fall in a few months from £3, and seems to show a desperate anxiety in America to turn metal into money. The general opinion is that this is quite an exceptional thing and not likely to be repeated.

International Tube Trade Agreement.

The latest information confirms last week's report of an international arrangement having been come to in the wrought iron tube trade somewhat on the lines of the International Steel Rail and the International Steel Joist Syndicates. At present the leading tube makers are very reticent as to what has really occurred, but it is generally believed that at least a provisional understanding has been arrived at. The German, French, and American works are reported to be concerned, together with our own.

Electric Light at Coventry.

The Coventry Electric Light Committee, in a report just issued, recommend that, subject to the sanction of the Local Government Board, the committee be authorised to expend the sum of £10,000 on extensions of distributing plant and £25,000 on the laying of new mains in the extended area of supply.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

Manchester, Wednesday.

A Depressed Market.

With the year tending to its close the depression in pig iron becomes more pronounced. The attendance on the Manchester Iron 'Change on Tuesday was quite up to, if somewhat above, the average, but one could hear in many directions that the market was "rotten." There was an utter absence of speculation, and orders were very contracted in character, and were only placed at the minimum of price. Up to the present there had been a difficulty in obtaining deliveries of iron from the makers, but the easier feeling is becoming more pronounced, and buyers are receiving intimations that there will be no such difficulty in the future. It is evident, therefore, that the extreme pressure of several months past has been relieved. Scotch iron certainly continues rather scarce, and prices are fairly maintained. On the other hand, although there is no official reduction in Lincolnshire, parcels are obtainable in second hands at 1s. per ton under last week's rates, and the same remark applies to Staffordshire. Hematite iron is again lower, but Derbyshire and Middlesbrough open brands remain on late levels. It is very probable, however, that with a firm order current rates would be shaded. Forge iron is also obtainable at about 1s. per ton less money.

Finished Iron.

There is no change to report, although bars and hoops are weak.

Steel.

The market is extremely dull, and there are offerings of foreign billets at 2s. 6d. to 5s. per ton under last week's rates. English are unchanged. Sheets and plates are quiet at the reduction of three or four weeks ago.

Copper.

Manufactured copper showed little change, but brass tubes, &c., were fractionally lower.

Sheet Lead and Tin Ingots.

Were in quiet request, the receding prices causing something of a relapse in this department. There is still room for lower rates in the manufactured as compared with the raw article.

Quotations.

Lincolnshire No. 3 foundry, 56s. 6d. to 57s. 6d.; Staffordshire, 55s. 6d. to 56s.; Derbyshire, 54s. to 55s.; Middlesbrough open brands, 58s. 4d. Scotch: Gartsherrie, 67s. 9d.; Glengarnock, 68s.; Eglinton, 64s. 9d.; Dalmellington, 64s. 3d., delivered Manchester. West Coast hematite, 66s.; East Coast ditto, 67s. 6d., both f.o.t. Scotch, delivered Heysham: Gartsherrie, 65s. 6d.; Glengarnock, 65s. 9d.; Eglinton, 62s. 6d.; Dalmellington, 62s. Delivered Preston: Gartsherrie, 66s. 9d.; Glengarnock, 67s.; Eglinton, 63s. 9d.; Dalmellington, 63s. 3d. Finished iron: Bars, £7 10s.; hoops, £8 2s. 6d.; sheets, £8 5s. Steel: Bars, £7 7s. 6d. to £7 10s.; hoops, £7 17s. 6d.; sheets, £8 10s.; boiler plates, £8 2s. 6d.; plates for tank, girder, and bridge work, £7; English billets, £5 5s. to £5 10s.; foreign ditto, £4 12s. 6d. Copper: Sheets, £78; tough ingot, £64; best selected, £63 per ton; copper tubes, 10d.; brass tubes, 8d.; condenser, 9d.; rolled brass, 6½d.; brass wire, 7d.; brass turning rods, 6½d.; yellow metal, 6¼d. per lb. Sheet lead, £18 5s. per ton. English tin ingots, £120 per ton.

The Lancashire Coal Trade.

There was a good attendance on the Manchester Coal Exchange, and the notice on the part of the West Lancashire Coalowners of an immediate advance of 6d. per ton in slack, nuts, burgy, and other descriptions of engine fuel was received with the meekness due to the inevitable. The Manchester district intimates a similar advance, to come into operation on the 1st January. Shipping demand is exceedingly quiet, with a rather downward tendency in prices. In house coal the future is very uncertain. All depends upon the weather, and with a continued cold spell, coupled with an absence of the usual winter stocks, members of the Coal Exchange said they would not be surprised to hear of a further advance of 10d. per ton. The outlook for merchants is, therefore, far from good.

BARROW-IN-FURNESS, Thursday.

Hematites.

The hematite iron trade seems weaker. There is less spirit in the market, and business is only being done on a comparatively small scale. Makers are, however, in some instances fairly well off for orders. But generally speaking the reverse is the case. As a consequence the output of metal is comparatively small, as is shown by the great falling off in traffics on the local railways. Prices are lower on the week. Makers are quoting 67s. for mixed Bessemer numbers net f.o.b., and warrant iron sellers are at 66s. net cash, while three months' deliveries are as low as 63s. per ton. This is an indication that the future of the market is considered to be unsatisfactory by those who want iron, but another view of the question is taken by several makers who have special knowledge of the trade, and who think that there is a good and hopeful sign of a better demand which they anticipate will spring into existence soon after the new year has turned. One strong feature of the position is that the stocks of iron held are lower than they were ever known to be in the history of the trade. The reduction of stocks this week, to the extent of 480 tons at a time when there is so small a demand, is eloquent of the good position in which makers are placed when any improvement in the market asserts itself. There is now in warrant stores only 5639 tons, and makers' stocks are almost non-existent. There are no speculative dealings in hematite iron at present, and makers would not be disposed to encourage them. There is a very quiet trade in iron ore, and prices are again lower at 13s. per ton net at mines.

Steel.

The demand for steel of all sorts is inanimate, and the business offering is only in small parcels. The rail mills are on short time, and frequently have to stop because of the scarcity of orders, while the merchant mills are worse off still. The trade in shipbuilding material is fairly well maintained, but orders are not well held. There are, however, prospects of a fairly steady business. Steel foundries are fairly busy, and new orders to supplement those already in hand are expected.

Shipbuilding and Engineering.

It is now known that Vickers, Sons and Maxim have secured the order for H.M.S. Rodney, and it is believed that other smaller orders have been booked at Barrow. The engineering shops are very busy, and further new orders are reported.

Shipping and Coal.

The exports of iron this week have been 3603 tons, and of steel 3309 tons, a total of 6912 tons, compared with 14,422 tons in the corresponding week of last year, showing a decrease of 7510 tons. The total exports this year have reached 805,257 tons, compared with 780,695 tons in the corresponding period of last year, a decrease of 24,562 tons. Coal and coke are in very poor sale, and there is a general depreciation in prices.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Christmas Holidays.

WEDNESDAY is admittedly an inconvenient day for Christmas to fall upon, having regard to business arrangements in the heavy industries. There is a pretty general feeling that it is scarcely worth while setting the furnaces "up" on the Monday, with the holiday season so close at hand. We learn, therefore, that it is the intention at several of the East End works to close after Saturday of this week to the Monday after Christmas, except in such departments as are required in respect of repairs. In other quarters the establishments will close from early on Christmas Eve for a week, or probably a day or two more. The pressure of work in particular departments, of course, operates to vary the holiday, as is invariably the case at the Christmas rest time. There is not much stocktaking now in the Sheffield district at this season of the year; but advantage is taken of the opportunity in several directions to make necessary repairs.

House Coal.

The weather has been exceptionally mild for the last few days, and the demand for domestic fuel, both local and general, has considerably diminished. Business with the metropolitan market, we are informed, is much less active; but the requirements of the Eastern Counties and other distant markets are stated to be fairly well maintained. There is, however, no weakening of values in any of the qualities now in request. Barnsley, in the best descriptions, make from 13s. to 14s. per ton; secondary sorts from 12s. to 12s. 6d. per ton. Anything like wintry weather would instantly quicken business in most quarters.

Steam Coal still Active.

Very good business continues to be done in steam coal, both on home and foreign account. The shipments to the Baltic ports must steadily attenuate as the season advances, but the exports to the lower reaches and to other markets are kept well up, the weight sent from Hull for the week ending 10th December last having been 75,671 tons, against 42,442 tons for the corresponding period of last year. Hamburg, with 8576 tons, heads the list, Rouen and Bremen coming next with 7985 tons and 7602 tons respectively. Heavy tonnages of locomotive fuel are being taken by all the contracting railway companies. In the open market the contract rate of 12s. a ton is exceeded by about 6d. a ton.

Pending Coal Contracts.

Supplementary contracts for locomotive fuel are now due for three railway companies, but we do not hear that any definite arrangements have yet been made. The principal of these is the North-Eastern Company, which has invited tenders for six and twelve months' supplies. It is not anticipated that the contracts now open will be renewed at anything under the contract rate of 12s. a ton at present ruling. The Humber steam fishing contracts, which also expire at the end of this month, are exciting interest in colliery circles. At the time of writing we do not hear of any arrangements for renewal having been made. The advance sought under the new rates will affect the trawling fleets materially, being stated at quite half-a-crown a ton above the rates now on the point of terminating.

Coke, Coking Slack, &c.

Coke is again a turn weaker, the quotations this week being from 12s. 6d. to 13s. 6d. per ton for best washed and 11s. 6d. to 12s. 6d. per ton for unwashed. The firmer demand noted last week for slacks for steam producing purposes is maintained. 7s. to 7s. 6d. per ton still ruling for best qualities, and 6s. to 7s. per ton for secondary descriptions. Manufacturing fuel for furnaces is also in good request at from 10s. to 12s. per ton.

The Iron Market.

Rather more business is reported in Lincolnshire and Derbyshire irons, though the volume of orders is not very large. The business done is both on early and forward account, the moderate rates ruling having induced a fair amount of buying for delivery during the first quarter of next year. There is not likely to be any change of prices this year. Current quotations are as follows:—Lincolnshire No. 3 foundry, 55s. 6d. per ton; No. 4 foundry, 55s. per ton; No. 4 forge, 54s. 6d. per ton; No. 5, mottled, white, and basic, 55s. 6d. per ton. Derbyshire No. 3 foundry, 57s. per ton; No. 4 forge, 55s. per ton. The iron departments in Derbyshire are stated to be steady, but not fully moving. Work in the foundries is reported to be somewhat better as regards the heavy branches.

Bars, Sheets, &c.

Bars are at the rate quoted previously, from £7 10s. to £8 per ton; sheets, £10 10s. per ton. In steel billets Bessemer are at £8 5s. per ton; Siemens, £8 15s. per ton.

The Heavy Industries.

The position remains as last reported. In the steel trade we do not hear of much new work coming forward; but, of course, it is a time of the year when orders usually slacken off somewhat. The tendency of late, however, has been towards less volume of work. There has been a decided falling off in the weight of material sent to the United States, and other markets have not yielded as much as during the earlier months of the year. More employment is much needed in the military and machine material departments. Railway work is well maintained for foreign and colonial markets, and in the new year, it is expected, the home companies will order more freely.

NORTH OF ENGLAND.

(From our own Correspondent.)

Trade Position and Prospects.

WHILE the iron, steel, and most of the allied industries were really "booming" at the commencement of the current half-year they are just the opposite at the close, trade having rapidly fallen off during the past few weeks, and now it may even be said that there is not a feature which can be accounted satisfactory. It is not surprising, therefore, that a generally pessimistic tone pervades the market, and people lack confidence with respect to next year's trade, so that few will buy iron or steel for delivery further ahead than the first two months. The tendency of prices continues to be downwards, and consumers, therefore, purchase from hand to mouth only, so that they may be able to take full advantage of the falling prices. Competition both at home and abroad is becoming very keen, and foreign prices are declining even more rapidly than our own, so that Continental consumers who have bought during the last two years from the Cleveland district are now satisfying nearly all their requirements at home, native producers being able to meet the demand now that the consumption has been reduced. The Luxemburg pig iron makers early this month declared a reduction in their pig iron prices 10s. per ton at one time, and now are accepting 12s. per ton less than at the commencement of this month. The price of pig iron is so much down that Cleveland iron will be kept out of Westphalia and the Rhine provinces, which hitherto this year have taken large quantities of British pig iron. A quiet period must be looked for over the greater part of next year, and Cleveland ironmasters are preparing for this by blowing out furnaces and seriously reducing the production. Up to the present twelve furnaces have ceased operations this quarter, though two are only damped down. Makers will not accumulate stocks to any considerable extent, and are thus following the course they adopted in 1900 when the period of prosperity was coming to an end, as it appears to be at the present time—they then blew out 20 per cent. of the furnaces. This, it is hoped, will check the downward movement in prices. The dulness in the shipbuilding industry is unrelieved, and the steel trade of this district is feeling the depression very severely, seeing that over 60 per cent. of the steel produced in the North-East of England is used by shipbuilders at home and abroad. The hematite pig iron business is now slackening very rapidly, and there has this month been a quick decline in prices.

Cleveland Pig Iron.

Demand is very slow, and makers seem to be getting well to the end of their contracts, so that the necessity comes in of their having to seek for more. They are, however, very chary about further reducing quotations, because there can be no doubt that they cannot make the iron for the prices that are to-day ruling, though coke has got back to a reasonable price once more; that is, as compared with the rate that can be realised for Cleveland pig iron, and this for the first time in nearly two years. No. 3 Cleveland G.M.B. pig iron has mostly been sold at 49s. 6d. per ton this week for early f.o.b. delivery, and No. 1 has been realising 53s. 6d. to 54s. A still less difference between the values of Nos. 1 and 3 is expected before the winter is over. The lower qualities of Cleveland pig iron are not in large supply, comparatively little being made. Producers have none in stock, and in the public warrant stores there is only about 7739 tons; but there are no warrants in circulation for it, and it appears to be held by one firm only. The price of No. 4 foundry is 49s., and of No. 4 forge at 48s. 6d. Mottled and white iron are almost unobtainable and unquotable, and there will be even less of it made now that the furnaces which need re-lining are being blown out. It is a long time since there was so small a proportion of the lower qualities made by the Cleveland furnaces.

Hematite Pig Iron.

Hematite iron has lately declined in price much more rapidly than ordinary Cleveland pig iron, and a lower quotation than this week's has not been known since 1905. Mixed numbers can now be bought at 64s. 6d. per ton, which, indeed, is the general rate, but consumers, as a rule, hesitate to give as much; it is considered too high a figure, and still lower prices are expected. When this month opened mixed numbers were quoted at 69s., and in November as high a rate as 76s. 6d. was ruling. This week's price is relatively higher than that of ordinary Cleveland pig iron, though not so much as it has been for the last eighteen months; indeed, in the summer there was a difference as large as 24s. 9d., instead of 15s. now. Rubio ore is becoming cheaper, and the Spanish mineowners are much more ready to accommodate consumers than they have been for months. Merchants are offering supplies at 16s. 6d. per ton, c.i.f., Middlesbrough, but consumers hold off for lower prices, which they generally expect. The rate of freight from Bilbao to the Tees, which was up to 5s. 10½d. per ton in the summer, has this week dropped to 4s. 3d. per ton.

Exports of Pig Iron.

These are on a smaller scale from the Cleveland district than they have been since February of last year. There has been no month since in which less than 100,000 tons has been exported. They declined very considerably during the first half of the month, but are expected to be considerably brisker in the second half, notwithstanding the holidays. The average shipment in the last year and three-quarters has been 130,000 tons per month. This month, up to Wednesday night, the exports of pig iron reached 60,932 tons, as compared with 89,055 tons last month; 79,577 tons in December, 1906; and 53,467 tons in December, 1905, all to 18th.

Pig Iron Stocks.

Though trade is becoming depressed, it is surprising to note that makers' stocks are not increasing, which perhaps may be attributable to the fact that so many furnaces have been blown out that the output does not exceed the requirements. The period of the year and the state of trade are not in favour of decreasing stocks in public stores, but, nevertheless, they are decreasing. The stock at the close of November was 95,941 tons, and on the 18th inst. the quantity was 87,792 tons, a decrease of 8149 tons. The stock consisted of 80,033 tons of No. 3 Cleveland pig iron, and 7759 tons of other qualities.

Manufactured Iron and Steel.

Generally the prospects are not good, and competition is becoming keener every day, especially with foreign manufacturers, but producers here will not reduce their quotations, and the consequence is that many orders are reported to go past them. Several of the works are irregularly employed. Messrs. Bolckow, Vaughan and Co., whose Eston steel works have been very irregularly employed for the last two months, are now able to give a better report. They have succeeded in booking some very large orders, which will necessitate their steel manufactory working more than regularly, for they will have to run on Christmas Day as well as New Year's Day. The Eston works have never since 1884 been in operation on a Christmas Day. The importance of the orders is therefore indicated. The West Hartlepool steel works, which were idle last and the previous week, have been in partial operation this week. Common iron bars are quoted at £7 15s.; best iron bars, £8 2s. 6d.; best best iron bars, £8 10s.; steel bars, £7 10s.; steel and iron ship plates, £7; steel ship angles, £6 12s. 6d.; steel joists, £6 7s. 6d.; packing iron, £6 5s.; steel hoops, £7 10s.; and steel sheets, £8 10s., all less 2½ per cent. f.o.t. Heavy steel rails can be got at £6 5s. net f.o.b.

Ironfounding and Engineering.

Ironfounders are having a very quiet time. The engineering works are still fairly well occupied, and for pumping machinery there appears a slight improvement in the demand. Parsons Marine Steam Turbine Company reports that during 1907 it has turned out six sets of marine turbine engines, of a total of 65,500 indicated horse-power, against four sets of 43,000 indicated horse-power in 1906. Three sets were for the British Admiralty and three for Japanese-built vessels. Improvement cannot be reported in the shipbuilding industry. Still it is reported that inquiries are out for five steamers for the Orient Company, and for ten Italian mail steamers. An order has been given out for a Canadian lake steamer to be built at Wallsend, and another for a 2200-ton steam collier to be built at Blyth. The shipbuilders and the representatives of the men have held two meetings within the last few days to discuss the question of a reduction of wages, notice having been given that such a reduction will come into operation on January 7th. No definite arrangement has yet been made. The men asked for an extension of the notice beyond the 7th prox., but the masters did not see their way to grant it.

Chair of Naval Architecture.

On Tuesday the founding of the new Chair of Naval Architecture, established at the Armstrong College, Newcastle-on-Tyne, was celebrated by a dinner held at the college under the presidency of the principal, Sir Isambard Owen, and the head of the new department, Professor J. J. Welsh, was then welcomed. This places the north-eastern district on the same footing as Glasgow and London in offering facilities for the teaching of this branch. The subject has been taught at the college for several years, but it has hitherto been bracketed with marine engineering under Professor Weighton. Out of the £1500 required, £1353 has been guaranteed for five years. Professor Welsh has commenced day and evening classes at the college, with a fair number of students.

Coal and Coke.

The coal trade is decidedly quieter; sellers are not so confident about the business of next year as they were, and prices are becoming weaker. Consumers consider the present quotations too high, and will not entertain the figures which the owners of collieries ask, especially when they can contract with second hands at lower rates. The North-Eastern Railway Company's coal contracts are in the market. Three quarters of a million tons are required, of which half a million usually falls to the lot of the Northumberland and Durham coal trade. In the year just closing the company has been paying 3s. per ton below the average selling price of the year, and the coalowners are for the forthcoming year asking 2s. 6d. to 3s. per ton more than they accepted twelve months ago. The price of best gas coals is 13s. per ton f.o.b., and Durham unscreened bunkers are at 12s. 6d. Coke has declined rather sharply in price, more quickly than most people expected, and for medium coke delivered promptly at the furnaces on Teeside 16s. per ton will now be taken, and ironmasters cannot very well complain of that figure when they are asking 49s. 6d. per ton for No. 3 Cleveland pig iron.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The General Business Position.

THERE is noticeable in several departments of industry a slight improvement in the unsatisfactory state of matters existing during the last few weeks. It is difficult to judge whether this movement has in it any permanence; it may be the result merely of the necessity that has arisen for certain kinds of work to be done before the New Year holidays. Whatever may be the cause, the change for the better, limited as it is, comes as a pleasing change. In Glasgow, it is stated on the authority of those connected with the Labour Exchange, there are more workmen out of employment just now than for several years past. A large proportion of the unemployed operators have been discharged from shipyards and engineering works during the last two months. It is so far gratifying to learn that in one or two instances preparations are being made for restarting portions of idle works. Should costs of production, and particularly the prices of fuel, continue to decline, there will soon be a prospect of more contract work coming into the market.

Pig Iron Warrants.

The pig iron warrant market has been quiet since last report. A scarcity of cash warrants has, amongst other causes, tended to curtail business. Reduced stocks and anticipated curtailment of output have not tended to strengthen the market, as they might be expected to do in normal circumstances. Curtailment of production and reduction of prices in America and on the Continent have tended to emphasise the depression in our market. Since last report a small business has been done in Cleveland warrants from 49s. to 49s. 7½d. cash, at 48s. 6d. to 48s. 3d. for delivery in one month, and 48s. 3d. to 48s. three months. Cumberland hematite warrants were done on Monday at 66s. cash —a reduction of 1s. 3d. per ton—but there have since been sellers at 63s. 6d. one month and 63s for delivery in three months. Scotch warrants are nominally 58s. and standard foundry iron 48s. 3d. per ton.

Output and Prices of Makers' Iron.

At the Wishaw Ironworks an additional furnace has been lighted to produce hematite pig iron, and there are now 42 making hematite, 39 ordinary, and 6 basic iron, the total of 87 thus in operation in Scotland comparing with 86 last week and 90 at this time last year. Some brands have been further reduced in amounts varying from 6d. to 2s. per ton. G.M.B., No. 1, is quoted at Glasgow 64s; No. 3, 60s. 6d.; Govan and Monkland, No. 1, 64s. 6d.; No. 3, 61s.; Carnbroe, No. 1, 66s.; No. 3, 62s.; Clyde, No. 1, 67s. 6d.; No. 3, 62s. 6d; Gartsherrie, No. 1, 68s.; No. 3, 63s.; Calder, No. 1, 72s. 6d.; No. 3, 67s. 6d.; Summerlee, No. 1, 71s. 6d.; No. 3, 64s.; Langloan, No. 1, 75s.; No. 3, 70s.; Coltness, No. 1, 90s.; No. 3, 69s.; Glengarnock, at Ardrossan, No. 1, 70s.; No. 3, 65s.; Eglinton, at Ardrossan or Troon, No. 1, 63s.; No. 3, 60s. 6d.; Dalmellington, at Ayr, No. 1, 65s. 6d.; No. 3, 60s. 6d.; Shotts, at Leith, No. 1, 73s.; No. 3, 65s. per ton. The demand for hematite pig iron is quiet, and Scotch hematite is down 2s. 6d., merchants now quoting 70s. per ton for delivery at the West of Scotland steel works.

Shipments of Pig Iron.

The shipments of pig iron from Scottish ports in the past week amounted to 5187 tons, compared with 10,127 in the corresponding week of last year. No iron was sent to the United States, but there was despatched to Canada 145 tons, South America 125, India 317, Australia 413, France 110, Italy 50, Germany 175, Holland 300, Belgium 30, China and Japan 200, other countries 125, the coastwise shipments being 3197 tons, against 3091 in the same week of 1906. The arrivals of Cleveland and district iron at Grangemouth were smaller than usual, amounting to 8378 tons, and showing a decrease of 248 tons compared with the imports of the corresponding week. The total imports for the year to date aggregate 409,913 tons, which is 16,360 tons more than in the same period of last year.

Finished Iron and Steel.

There has been a little better inquiry since last report for both finished iron and steel. The orders coming to hand are generally of small or moderate proportions, and for prompt delivery. One or two works have still little or nothing to do, and there is a prospect of operations being suspended for a longer period than usual at the holiday time. Merchants report that there has been an increasing inquiry for various kinds of goods, out of which it would be natural to expect that business should come later. In the meantime there is some difficulty with values owing to the keen competition at home and the comparatively low prices quoted by foreign houses.

The Coal Trade.

The inland department of the coal trade has been active in consequence of cold and stormy weather. Household coal has sold in large quantity, and the prices have been well maintained. On the West Coast the coal shipments have been rather larger, but there was a heavy decrease at some of the East Coast ports, due in some measure to vessels being detained by stormy weather. At Glasgow harbour house and steam coal are quoted 13s. to 13s. 6d., and splint 14s. 6d. to 15s. per ton.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Welsh Coal Trade.

THE weather has continued to interfere greatly with business, and it is regarded as showing the vitality of trade that prices have not been sensibly affected, and this gives the belief that when climatic changes do take place there will be a brisk rally. As it is, a strenuous stand is made against much lower prices, and it will be seen that quotations do not vary much from those of last week. Small steam coals are a little higher. Monmouthshire best continue steady. Newport has received a very large tonnage during the last few days. On one day sixty-seven vessels, many of good size, were in dock, and at other ports the improvement is such as to justify the belief of authorities that after the usual quietness of the festive season there will be for a time a strong demand. The firmness of best second steam is instanced as a trustworthy indication of trade. The best steam coal is at 18s. 6d. to 19s.; seconds, 17s. 9d. to 18s. 3d.; ordinary large steam, 17s. to 17s. 6d.; drys, best, 19s. to 19s. 6d.; ordinary, 17s. 6d. to 18s. 6d.; best Monmouthshire, 17s. 3d. to 17s. 6d.; Western Valley, 17s. to 17s. 3d.; Eastern Valley, 15s. 9d. to 16s. 3d.; best house coal, 19s. 6d. to 20s. 6d.; seconds, 17s. to 18s.; No. 3 Rhondda, 19s. 6d. to 20s. 6d.; through and through, 16s. to 16s. 6d.; No. 3 smalls, 12s. 6d. to 13s.; No. 2 Rhondda, 15s. to 15s. 6d.; through, 11s. 6d. to 12s.; No. 2 smalls, 9s. 6d. to 9s. 9d.; best washed nuts, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d.; best washed peas, 13s. to 13s. 6d.; seconds, 12s. 9d. to 13s.; best smalls steam, 10s. 9d. to 11s. 3d.; seconds, 9s. 6d. to 10s. 3d.; other smalls, including dry, 8s. to 8s. 6d. Patent fuel, 18s. to 18s. 6d.; coke, furnace, 18s. to 19s.; foundry, ordinary, 21s. to 23s.; special, 25s. to 27s.; pitwood, this continues to improve in price; latest, 25s. 6d. to 26s.

Anthracite.

The change in price is inconsiderable. At Swansea this week it was stated that though quotations remained slightly less, prices were taken to get wagons relieved. The demand is strong, and outlook distinctly favourable with better weather. In the Swansea district the collieries are busier. Gwendraeth district is very brisk. Latest Swansea prices are:—Best hand picked malting, 29s. to 30s.; seconds, 27s. to 28s. 6d.. Swansea Valley big vein, 24s. 6d. to 26s. Red vein, 20s. to 21s.; machine made cobbles, 27s. to 28s.; nuts, 27s. 6d. to 28s. 6d.; peas, 14s. to 16s.; rubbly culm, 7s. 3d. to 7s. 6d.; duff, 5s. to 5s 3d. Other quotations are:—Best steam, 18s. 9d. to 19s. 9d.; seconds, 16s. 9d. to 17s. 6d.; ordinary large bunker, 14s. 9s. to 15s. 3d.; through, 13s. 3d. to 13s. 9d.; small, according to quality, 8s. 6d. to 10s. No. 3 Rhondda, 20s. to 20s. 6d.; small, 13s. 3d. to 13s. 9d. Patent fuel, 17s. to 17s. 8d. Patent fuel has been despatched this week to France and Algiers. One cargo to the latter was 3900 tons.

Colliery Explosion in Glamorgan.

Another colliery accident took place last week, this time at Gilfach Coch, a well-managed colliery belonging to the Britannia Company. It occurred on Saturday, when the large majority of the men were up at the pay office. The loss of life was limited on this account to seven, and, as the inquest has been opened, fullest investigation is certain. The colliery is in the Ogmore district. The falls are said to be considerable. One feature of the disaster was the presence of white damp, which is far more dangerous than the ordinary black damp. White damp is really carbon monoxide, and a very small quantity inhaled for a brief period causes death, and in the explosion in question its effects were quickly overpowering.

Iron and Steel.

Ironmasters are noting carefully the course of business in America. One of the latest announcements is that it has been decided there to lower the price of raw and finished steel 10s. at port of shipment. This may be expected to presage a droop in prices. Germany is quoting Bessemer steel billets to this country at £4 15s The latest prices given out at the Metal Exchange, Cardiff, this week were: Bessemer steel bar £5 to £5 2s. 6d., and Siemens £5 5s. per ton delivered. Prices of pig iron show little change. Hematite: Bessemer mixed numbers are quoted at 66s. 1½d., instead of 67s. 7½d.; Middlesbrough a small advance; Scotch a decline of 1s. to 58s. Welsh hematite remained at 72s. 6d. Very few imports of pig iron have taken place, and this week one only from Middlesbrough. Several important consignments have come from Antwerp, one nearly 2000 tons to Newport, composed of steel blooms, wrought iron rails, steel plates, bars, and crop ends. From Bilbao a cargo of wrought boiler covers came to Newport. In exports a fair quantity of steel sleepers was despatched foreign, but the chief make at leading works has been heavy and light rails for this country, fish-plates and angles. Mills have been tolerably busy, but the weather in all quarters has interfered a good deal with outdoor employment. Little animation in trade Iron ore was quoted this week at 15s. 3d. to 15s. 6d. Newport or Cardiff; Rubio and Almeria the same. Other quotations:—Swansea, copper, £57 5s.; spelter, £20 5s.; silver, 25d. per oz. A tolerable quantity of iron ore has come into Welsh ports from Bilbao and Caen.

Tin-plate.

Trade rather quiet, but a large shipment last week from Swansea—104,551 boxes; mills active, and 64,034 boxes were turned out, leaving stocks at 143,545. Makers are relieved by lesser prices of raw material. Block tin is £116 12s. 6d. per ton. Eastern trade dull. Prices are lower. The quotations on Metal Exchange, Swansea, this week were as follows:—Ordinary plates, Bessemer, 20 × 14, 112 sheets, 12s. 9d.; ternes, 24s.; C.A. roofing sheets, £10 per ton; big sheets for galvanising, £9 10s. to £9 15s.; finished black plates, £10 to £10 5s.; galvanised sheets, 24 g., £13 2s. 6d. At Llanelly the bar requirement is chiefly obtained locally, and little concern is felt about American rivalry. That prospects are tolerably good may be inferred from the fact that additional mills are to be put down by the Old Castle Company.

Swansea Valley Industries.

A good average of steel bars has been made of late. Spelter trade continues brisk, but copper rather slow. Good business continues at the Mannesman tube works at Landore.

Ebbw Vale Works.

Mr. Wm. Lintern, assistant engineer at Beardmore and Co.'s Parkend Works, Glasgow, has been appointed chief engineer at Ebbw Vale. He began his career at Dowlais Works.

Swansea Dock.

Substantial progress is being made with this great undertaking, which is being efficiently carried out by the contractors, Topham, Jones and Railton. The time of the contract was to 1910, but there is a likelihood of completion by August, 1909. A few days ago members of the Harbour Trust, the Corporation, and others made an official inspection, and reported favourably. About five-eighths of the walling of the new dock has been completed, and nearly half of the three million tons to be excavated has been accomplished. The huge lock is also practically complete. I hear that contracts have been placed for hydraulic machinery, and specifications got out for the cranes and other equipments. One satisfactory feature is the agreement, practically, of all the railways interested to have the coal appliances on high level, the same as at Barry. The lock is 875ft. in length and 90ft. wide, and will accommodate the largest vessel afloat. The total area of the dock is over 71 acres.

NOTES FROM GERMANY.

(From our own Correspondent.)

Rheinland-Westphalia.

RATHER unfavourable accounts have come in during the week, the downward movement having been more marked than before. Reductions in price are the order of the day. The Steel Convention resolved to reduce the inland quotations for sectional iron, and for semi-finished steel M. 10 p.t. for the first quarter in 1908; and the hoop mills reduced their prices, on an average, M. 10 and M. 12·50 p.t., the basis quotation now being M. 137·50 p.t., free Dortmund, for orders exceeding 30 t., while for less than 40 t. M. 140 p.t. has to be given. The Union of Sheet Mills, on the other hand, raised the basis price M. 10 p.t., because the price for semi-finished steel had only been reduced M. 10 p.t., instead of M. 20 p.t. The steadily decreasing prices of plates and bars have caused Berlin dealers to lower their quotations further. On the 13th of November the Union of Bar Merchants had reduced bars in basic to M. 150 p.t., those in iron to M. 170 p.t., while iron plates were reduced to M. 165 p.t. The reduction again resolved upon is M. 10 p.t., so the price free Berlin stores will be M. 140 p.t. for bars in basic, and M. 160 p.t. for iron bars, while plates are quoted M. 155 p.t. The brisk activity and favourable prospects in the railway and engineering departments continue.

Silesian Iron Trade.

Makers of pig iron as well as of malleable iron so far are well employed, but the amount of fresh work coming in is small, and an abatement in activity is likely to be soon felt, for next to no speculative business is being done, and the old orders are being executed now. Competition is very keen, and prices inclined to move downwards.

Coal in Germany.

Increasing demand for house fuel is reported from all the coal-producing districts. The position of prices is exceedingly firm; here and there advances have been resolved upon.

Steady Demand in Austria-Hungary.

A regular business is done generally in the iron and steel trades; pig iron is pretty strongly inquired for, chiefly for immediate consumption. Forward orders are scarce, purchasers showing much reserve as regards next year's requirements. The mills engaged in the production of bars and plates continue well employed, and the prices realised are pretty remunerative. The downward movement on the international iron market is already being felt in Austria-Hungary, for, owing to decreasing inland and foreign demand, German firms are making most energetic efforts to find a market for their articles in Austria. A few weeks ago the Phœnix Ironworks opened an office for sale in Vienna, and other firms have done the same now. Only the Rhenish-Westphalian works, however, can be successful competitors, for agreements exist between the Austrian Iron Convention and the German syndicates concerning the protection of the places of sale; unfortunately, the said agreement will end with the present year. The Austrian Plate Convention has already been induced by the German competition to reduce its prices, and further reductions are likely to take place. The situation of the Austro-Hungarian coal market is as satisfactory as before, prices being firm, and demand increasing. The Bohemian brown coal trade continues to be influenced by the scarcity of wagons, which has caused a stagnation in the export trade, in spite of a brisk demand. During November of the present year 395,542 t. have been delivered, or 19,071 t. less than in the year before. The Elbe traffic and exports to Bavaria also show a falling off. Last week Turkish coal was brought to Budapest by a tugboat of the Danube Steamboat Company; the price is 3 crowns p.q., free Budapest.

Weakness in Belgium.

Not merely has the inland demand been decreasing perceptibly, but the business on foreign account has also become languid and irregular. The rolling mills complain of the poor, hand-to-mouth sort of trade that is being done, and of the strong and often successful competition of the German shops. Firm prices for finished articles are out of the question, producers being compelled to agree to the prices offered, whether remunerative or not, just because they wish to keep their works regularly occupied. Sales on the Belgian coal market are lively, and also rather extensive. Small coal is sold at 15f. to 16f. and 17f. p.t., engine coal realising from 16f. to 19f. p.t. Here and there an abatement in the demand for engine fuel could be felt.

Iron and Coal in France.

The condition of the iron trade is much as reported previously; activity on the whole has been decreasing, and prices show a weakening tendency. An exceedingly firm tone characterises the French coal market, consumption being heavy in spite of the slight abatement in the demand for engine fuel.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, December 5th.

THE quotations which machinery makers and the managers of some of the larger engineering plants have been giving out on work which their agents sought have rather suddenly dropped in a volume of orders from railroad shops, car shops, and engineering plants and foundries, which has imparted quite a stimulus to the machinery business for the time being. The cost of machinery has been steadily advancing for over two years, and even with these higher prices the manufacturers of machinery have been unable to fill all the orders presented. Not a little business has been lost because of high prices. With the decline in crude iron and finished steel during the past two or three months, the builders of machinery saw an opportunity for securing business by lowering quotations. This they have done. As a result, the agents of these establishments have succeeded in the past week or two in closing a large amount of business, with prospects for securing a great deal more. This condition of things has lightened up the situation considerably. It has led to some little demand for those grades of pig iron generally used in the construction of machinery. One of the orders just secured comes from the Boston and Albany shops at Springfield, and amounts to 75,000 dols. This is a pointer, and a good many more heavy orders are now on their way. Besides during the recent dulness quite a number of plants caught up with their orders, and are now able to promise earlier deliveries. The possibility of many of these plants filling up with business no doubt acts as an incentive with some people to place their orders so that they can be assured of early delivery. An interesting feature of the trade is the improving demand for machinery from Mexico, Cuba, Porto Rico, India, and Japan. The new steel plant in Japan and the projected great steel works in Australia, and the great steel works to be built in India, will all bring considerable business to American machine makers.

The copper market is easier, and exports for the month ending November 28th foot up 31,992 tons. Prices are 14c. for Lake, 13⅞c. for electrolitic, and 13c. for casting. The evidences point to quite a large increase in copper production. Those who wish to keep in touch with the copper situation on this side would do well to watch the Guggenheim operations in railroad construction in the rich copper fields of Alaska. In other metals no change has developed, and prices are substantially without change.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. R. A. TONNE asks us to state that he has opened an office at 133, Boulevard de la Senne, Brussels.

THE Gandy Belt Manufacturing Company asks us to state that it has installed a second telephone in its London office. Its number is now Bank 832—two lines.

WE are asked to state that Messrs. Murray, Lotz and Co., of 102, Fenchurch-street, E.C., have been appointed by the Partick Brass and Copper Works (A. Low), Glasgow, as their sole agents for England and the Continent.

THE Continuous Rail Joint Company, Limited, has received further orders from the contractors, Messrs. J. G. White and Co., Limited, for the supply of its patented continuous rail joint for the Perth Tramways (W.A.), also for Dumbarton and South America.

THE INSTITUTION OF CIVIL ENGINEERS: ASSOCIATION OF YORKSHIRE STUDENTS.—By permission of the Park Gate Iron and Steel Company, Limited, a visit will be paid to the Park Gate Works, Rotherham, to-day, Friday, December 20th. The company has invited members to lunch at Parkgate Works at 1.15 p.m., after which the visit will commence.

THE British Vice-Consul at Sofia reports "that the Bulgarian Government are rapidly extending their system of railways, and an opening thus presents itself for the supply of coal, locomotives, rolling stock, iron bridges, and rails. Besides Government requirements, there are various municipal enterprises in which British contractors and manufacturers should obtain a share, such as electric lighting, traction, &c."

CONTRACTS.—The recent orders received by the Gilbert Little Company, Limited, Horton Works, Bradford, comprise elevators and conveyors for the new slag reduction works at Cargo Fleet, Middlesbrough, and a system of conveyors on the floors of the new mills of the British Paper Company, Limited, London.—We are informed that Bateman's Machine Tool Company, Limited, of Balm-road, Hunslet, near Leeds, has secured the contract for the supply of planing machinery for the Quarry Bay Shipyard, Hongkong. The order includes a 60in. by 60in. by 12ft. planer, fitted with three tools, and arranged to give variable cutting speeds, together with a constant return speed. The drive will be by electric motor in the larger machines, and by belt in the smaller tools.—Messrs. L. P. Winby and Co., of Queen Anne's-chambers, Tothill-street, S.W., have recently received a repeat order from the Liverpool Overhead Railway Company for a supply of their "Winby" patent anchor chairs.—The Gandy Belt Manufacturing Company, Limited, has received an order for 700ft. by 42in. wide Balata belting, for a breakdown on the Continent, which has to be made and shipped within a week.—In connection with recent extensions of the West Ham Corporation electricity works, a water-cooling plant for 250,000 gallons per hour, on the Gjers and Harrison's Simplex spraying nozzle system, has been put to work. At the Eastbourne Corporation electricity works a plant for 70,000 gallons per hour on the same system has also been put down.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS, *M.I.Mech. E.***

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.
When the abridgment is not illustrated the Specification is without drawings.
Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.
Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

27,693. December 5th, 1906.—IMPROVEMENTS IN OR RELATING TO MEANS FOR PROMOTING CIRCULATION IN STEAM BOILERS, Circulators, Limited, 118, Leadenhall-street, E.C., and Harry Schofield, 9, Mark-road, Wood Green.

This invention has reference to the promoting longitudinal circulation in steam boilers, and is applicable more particularly to boilers of the Lancashire, Cornish or Galloway type. There are two figures. Fig. 1 is a longitudinal section of part of a Lancashire boiler, showing the improvements. *a* is the body or shell of the boiler; *b* is one of the two ordinary internal flues, which in this case are unprovided with cross tubes; and *c* represents the fire bridge. *d* is the circulation chamber, sheathing or casing with which the furnace, or each furnace, is provided externally. This chamber is made of as large a cross-sectional area as convenient. It consists of an annular jacket or chamber of flat rectangular section, formed by securing a plain thin metal sheet around two of the flanges *b*¹ of the furnace plates, so that the flanges form the sides of the chamber or casing, and there is a very large heating surface relatively to the thickness of the body of water in the

Nº 27,693.

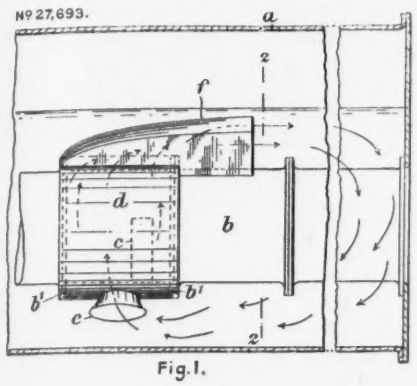


Fig. 1.

sheathing or casing. The sheet is concentric with the wall of the furnace, which latter forms the inner wall of the annular circulation device or chamber. It is folded round the furnace outside the flanges, and is kept in position by tightening bolts arranged at the dotted line to draw the ends of the sheet up tight. In order to assist in stiffening the sheets, a ring of angle iron, parallel with but midway between the flanges, may be fitted around the ring to support it, and to withstand the strain of the bolt. *e* and *f* are the nozzles serving as the inlet and outlet of the circulation chamber *d*. The upper nozzle or cowl *f* is box-like or rectangular in form, and extends some little distance along the furnace. The water inside the circulation chamber *d* becomes highly heated, and bubbles of steam form therein, so that the water begins to rise in the manner of a convection current. On this current reaching the outlet box or nozzle, the cover of the latter serves to throw it in a longitudinal and more or less horizontal direction along the top of the furnace. Meanwhile water is also entering the lower nozzle, and thus the desired bodily circulation of the water is effected as indicated by the arrows.—*November 30th*, 1907.

INTERNAL COMBUSTION ENGINES.

25,853. November 15th, 1906.—IMPROVEMENTS IN OR RELATING TO FOUR-CYCLE EXPLOSION ENGINES, *Bruno Zinke, of 8, Luisenstrasse, Saarbrucken, Germany.*

The idea of expelling the residual products of combustion from the cylinders of gas engines for the purpose of increasing the power

Nº 25,853.

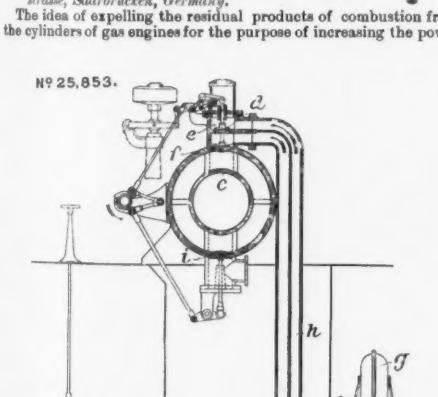


Fig. 1.

and the thermic efficiency of the engine is well known. This invention gives a practical method for expelling the residual products of combustion from gas engines of the four-cycle type, that being effected by air which enters the cylinder through the main inlet valve under approximately constant pressure. To obtain diagrams always uniform, the first condition is that the gas and air should be as far as possible under the same pressure, and that the said pressures should practically remain the same relatively to each other. For this reason, the air in the air pipe is placed under pressure by means of a separate air pump. This pressure corresponds to that in the gas pipe, and amounts to about 100 cm. water column above atmospheric pressure. There are three figures. Fig. 1 is a cross section through the cylinder showing the gas and air admission device. The gas is under pressure in a gas receptacle *a* provided underneath the engine, and proceeds to the cylinder *c* through a tube *b*. By means of a regulated valve *d* controlled by the regulator, the gas is admitted into the mixing space *e*, and from this, by mean of a regulated valve *f*, into the cylinder together with air. The air proceeds by means of a fan *g* driven by the engine through a pipe *h* into the mixing space *e*, and is kept continuously under pressure. The combustion gases are discharged by means of a regulated valve *i* arranged in the lower part of the cylinder *c*. The main inlet valve is opened during the last part of the exhaust stroke. Air then enters the cylinder from the space *e* and rinses or sweeps out the remaining residues of combustion through the still open outlet valve *i*. On the closing of the outlet valve at the end of the exhaust stroke the gas inlet valve *d* is opened. The gas thereupon enters with the air, which is normally under pressure during the suction stroke, into the cylinder. The gas inlet valve *d* is only closed towards the end of this stroke, and the inlet valve *f* at the end of the stroke itself. In this manner the presence of any residuary gas in the mixing space is avoided, so that on the opening of the inlet valve *d* during the exhaust only pure air enters the cylinder.—*November 29th*, 1907.

TURBINES.

18,413. August 16th, 1906.—IMPROVEMENTS IN AND RELATING TO ELASTIC FLUID TURBINES, Sebastian Ziani de Ferranti, of 31, Lyndhurst-road, Hampstead, N.W.

This invention relates to elastic fluid turbines using either gas or steam, and is applicable with especial advantage to turbines using high temperature working fluid. In dealing with turbines using a high temperature working fluid, it is found that when using a turbine of the Parsons pressure flow type to convert the heat energy of the working fluid into work, the length is increased in comparison with that of a turbine using saturated steam with the same pressure range. This is due to the much greater amount of energy in the working fluid at the high temperature, and the consequent greater number of rows of blades to convert it usefully. The main object of this invention is to decrease the losses to which the working fluid is subject in its course throughout the turbine, so as in many cases to make it possible to construct turbines which

Nº 18,413.

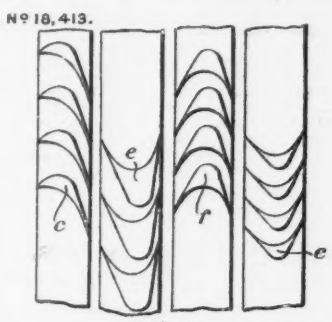


Fig. 6.

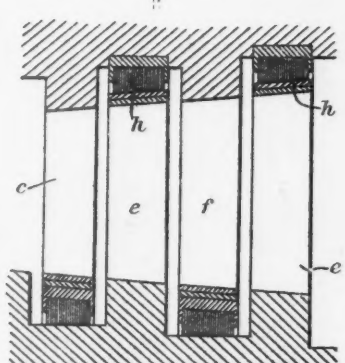


Fig. 7.

will efficiently utilise the working fluid. There are eleven figures. Fig. 6 shows a method of applying the packed "impulse" blades. Fig. 7 is a part section through the blades of Fig. 6 by way of example, to show both nozzle and "impulse" blades packed. The individual blades *e* have a symmetrical cross section, but being angled with regard to one another, so that the inlet is of greater breadth than the outlet. To compensate for this loss of dimensions, the blade is formed of increasing length in the direction of flow. One row of nozzle blades *c* may be combined with two or more sets of running blades *e*, and one or more sets of standing return blades *f*, such blades *e* and *f* being formed to secure coalescence of adjacent jets, and being provided with efficient packing. Fig. 7 shows the application of packing *h* to these "impulse" blades. The method of construction of nozzle blades with the velocity generated therein fractionally abstracted by packed "impulse" blades is especially suitable for gas turbines, but instead of a number of stages being used, *i.e.*, instead of the arrangement of Fig. 6 being repeated a number of times, in most cases only one set of nozzle blades with a sufficient number of sets of packed "impulse" blades will be required, and instead of the circular jet issuing from a contracting path between the nozzle blades, the blades will be so formed as to give the necessary increasing area for dealing with the high temperature drop necessary in the nozzles of a gas turbine.—*November 29th*, 1907.

SUPERHEATERS.

23,175. November 19th, 1906.—IMPROVEMENTS IN AND CONNECTED WITH STEAM SUPERHEATERS, George R. Sisterson, of 12, Great James-street, Bedford-row, W.C.

This invention relates to the type of superheater which is placed within the smoke-box of a locomotive boiler, and is fitted with fire tubes which are arranged contiguous to or entering into the fire tubes of the boiler so as to permit cleaning of the latter, the heated gases from the boiler fire tubes passing through the fire tubes of the superheater on their way to the funnel. The invention consists in disposing a series of partitions extending from tube to tube in the header, in such relation to the partitions dividing up the annular space between the concentric tubes that they divide the header into a number of longitudinal chambers, some of which communicate with an inlet steam chest and with the inlet side of the said annular space, and the others with an outlet steam chest and with the inlet side of the said annular space, and the others with an outlet steam chest and with the outlet side of the annular space. There are five figures. Fig. 2 is a side sectional elevation. The superheater, for convenience in erecting, is made in two portions, one arranged on each side of the usual blast pipe and opposite to the upper series of fire tubes of the boiler. Each portion comprises a header or steam chest *a*, which is fitted with a number of short fire tubes *b*, arranged next the fire tubes *c* of the boiler. Each fire tube *b* of the superheater is surrounded by an outer tube or jacket so as to form a steam-tight annular space *c* communicating with the header. Each fire tube *b* may be passed right through the header *a* from the rear wall out through the front wall and project some distance on the other side. The respective outer tube or jacket *d* is welded at its one end to the outermost end of the fire tube *b*, whilst its inner end is somewhat tapered and fits into a corresponding hole in the front wall of the header, the outer tube or sleeve at this end being formed with a collar *f*.

Nº 26,175.

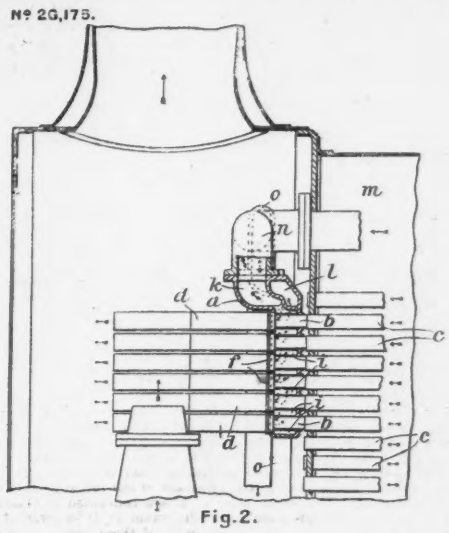


Fig. 2.

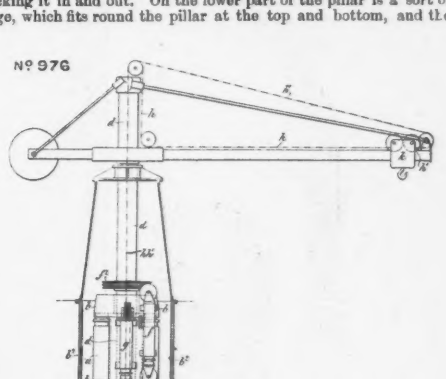
The annular chamber thus formed is divided by partitions extending nearly throughout its length, and similar partitions are arranged between the tubes in the header, so that steam from the header is obliged to pass right along the annular space from the inner end to the outer end, and then around the end of the partition, back again from the outer to the inner and into the header. The partitions in the header divide it into a number of chambers, some of which communicate with an inlet connection or chest *k*, and the others with an outlet connection or chest *l*, the steam being let into one set of chambers, passing thence through the annular spaces of the respective tubes into the other chambers, and from there to the outlet. The steam is led by a pipe *n* from the boiler *m* to the inlet *k* of each header, and after passing through the superheater is led off from the outlet *l* through the usual steam pipe *o* to the respective cylinder, it being arranged that in a superheater made in two portions one header supplies one cylinder and one the other cylinder.—*November 30th*, 1907.

CRANES.

976. January 14th, 1907.—IMPROVEMENTS IN HYDRAULIC CRANES, Frederick W. Tannett-Walker, of Hunslet, Leeds.

In this invention the jib is turned and the monkey is racked in and out by cylinders, which are raised and lowered with the crane pillar. The turning cylinders act, as usual, by chains reeved round them and passed round a chain wheel, which is keyed on to the pillar. The racking cylinders act on two wire ropes through pulleys. These ropes pass up the centre of the hollow pillar, one leading to one side of the monkey and the other to the other, thus racking it in and out. On the lower part of the pillar is a sort of cage, which fits round the pillar at the top and bottom, and the

Nº 976


k
h
d
b
b
b

ROAD MOTOR VEHICLES.

27,860. December 7th, 1906.—IMPROVEMENTS IN OR RELATING TO THE MOUNTING OF MOTORS, MECHANISM, OR THE LIKE ON FRAMES SUCH AS THE FRAMES OF AUTOMOBILES, Frederick H. Royce, of Cooke-street, Hulme, Manchester.

The object of this invention is an improvement to the usual method of suspending an engine from a motor car frame. The usual method hitherto has been to fix the engine rigidly to the side members. Should a car on which the engine is rigidly fixed travel over any uneven road the side members move relatively to each other and are limited in their movement by the arms of the engine, thus producing an extra strain on the crank chamber. The subject of this invention is a method of supporting the engine

Nº 27,860.

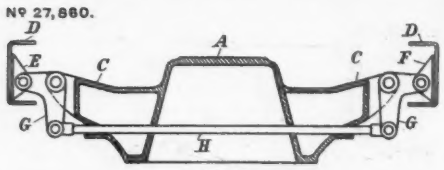


Fig.2.

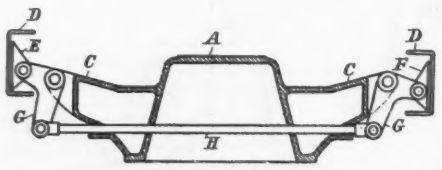


Fig.3.

from the side members of a car frame. There are three figures. Fig. 2 shows in sectional elevation an engine suspended from a motor car frame. Fig. 3 shows the action of the mechanism when one side member of the frame moves relative to the other. The crank case A has four arms projecting from it B, B, C, C. The rear arms B, B are fixed to side members of the frame D, D in the usual manner. The front arms C, C are connected to brackets E, F bolted to the side members of the frame D, D by levers G, G having pinned joints. The lower ends of these levers G, G are connected together by a tie rod H. Should one of the side members of the frame D, D move relatively to the other, the centre of the crank case will remain stationary relatively to the centre of a line drawn from the centre of the suspending bracket E to the centre of the other bracket F.—*November 29th*, 1907.

MISCELLANEOUS.

28,573. December 14th, 1906.—IMPROVEMENTS IN THE MANUFACTURE OF CERTAIN MOLTEN METALS AND APPARATUS THEREFOR, Benjamin H. Thwaite, of 29, Great George-street, Westminster, and Wolf Defries, of 147, Hounsditch, London, E.C.

The purpose of this invention is to obtain a more complete control over the composition of certain molten metals, such as steel, in the preparation of which large quantities of air or gas may be forced under pressure through the molten metal, and to shorten the process of manufacture which has been necessary

Nº 28,573.

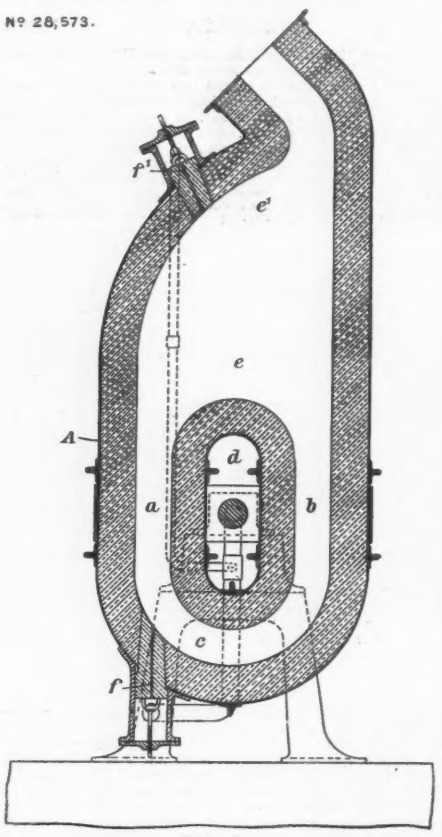


Fig.1.

hitherto for obtaining and refining a homogeneous product. The invention consists in so directing the blast from such a position that the entire mass of the metal receives a systematic, regular and uniform movement of circulation. There are seven figures. Fig. 1 is a sectional elevation of the apparatus. The metallic mass intended for treatment is run into a vessel A composed of two vertical tubular limbs *a*, *b*, communicating with each other through a continuous passage *c* in the lower part of the vessel and having an air space *d* closed at top and bottom between the inner faces of the vertical limbs *a*, *b*, extending from the top of the level of communication to the underside of the upper level above which the tubes coalesce to for a common chamber *e*. The external part of this vessel is made in three portions, the upper and the lower portions being slipt vertically for convenience of lining. The upper part e^1 is contracted into somewhat the form of the throat of an ordinary Bessemer converter. The vessel A is lined with refractory metal. The metal is filled to such a height as to overflow the top of the tubular limbs *a*, *b*, into the chamber *e* forming the upper part of the vessel which connects the tubular limbs, so as to provide a continuous volume of liquid metal above which the slag floats. The working level of the metal is thus in all cases above the top of the diaphragm or body dividing the converter. At a point in the lower part of the vessel tuyeres *f* are arranged through which air under pressure can be forced up one of the two vertical limbs. A suitable pressure of air effects a vigorous circulation of the molten metal, which flows up one limb *a* of the vessel and down the other limb *b*. A supplementary tuyere f^1 may be arranged in the upper part of the vessel to assist the downward flow through the limb *b*. A special purpose of this circulation is that if the metal in its downward circulation carries with it the slag or some proportion of it, that proportion will in this way be mixed more intimately with the mass of the metal than if it lay merely on the surface; and it will finally settle out when the vessel is tilted and the circulation is consequently finished.—*November 30th*, 1907.

26,665. November 23rd, 1906.—IMPROVEMENTS IN AND RELATING TO THE MANUFACTURE OF MAGNETIC MATERIAL, Robert A. Hadfield, of Parkhead House, Sheffield.

This invention has reference to an alloy having magnetic and electric properties especially adapting it for use in ballast coils, transformer plates, and like electrical apparatus, wherein it is of great importance to reduce the total magnetic and electric losses to the lowest possible degree; and also having improved physical properties, in point of solidity and homogenity of structure, when in the cast or moulded condition. The inventor discovered that castings of a magnetic alloy of iron, silicon, and aluminium can be physically improved by the addition to an alloy of iron and silicon, whilst the same is in the molten state, of aluminium to an amount not exceeding 1·3 per cent., in that such castings are rendered more free from blow-holes and like imperfections, and from any tendency to boil when in the molten state, while also becoming much more solid and homogeneous in structure than when the aluminium is not added. Pure iron is melted, with from ½ to 5 per cent. of silicon, in such proportion as to enable the total magnetic and electric losses in the alloy to be reduced by heat treatment to values below those which take place with the purest iron commercially obtainable, and to the molten alloy of iron and silicon is added aluminium to an amount not exceeding the stated amount. The alloy may be cast in ingots in the usual manner. The alloy should be low in carbon, say, under 0·12 per cent. It should also be low in manganese, unless the alloy is to be reduced, as by rolling, into sheets or other thin forms, in which case an addition of manganese up to about 0·7 per cent. may be made in order to increase the working and rolling qualities of the alloy without unduly impairing the magnetic qualities thereof.—*November 29th*, 1907.

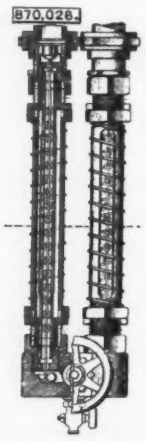
SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

870,026. WATER GAUGE, *H. R, Fay, Boston, Mass. — Filed April 1st*, 1907.

This invention consists in putting in a chain, which nearly fills the

870,026.

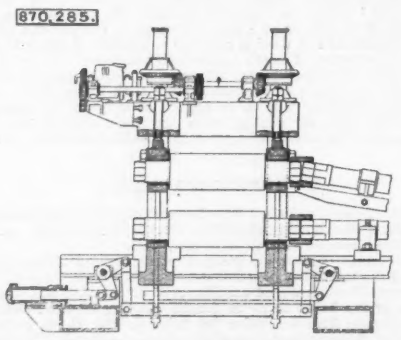


glass. On the end of the chain is hung a ball. If the glass breaks, the chain crumples up, pulling the ball on to a seat, and so preventing the escape of hot water. There are four long claims.

870,285. HYDRAULIC COUNTERBALANCE FOR ROLLING MILLS—*A. K. Hamilton, New Brighton, N.Y., and A. T. Keller, Pittsburg, Pa.; said Keller assignor of one-half of his right to Mesta Machine Company, Pittsburg, Pa., a Corporation of Pennsylvania.—Filed November 2Ath*, 1905.

The roll bearings are carried on a transverse beam under the

870,285.

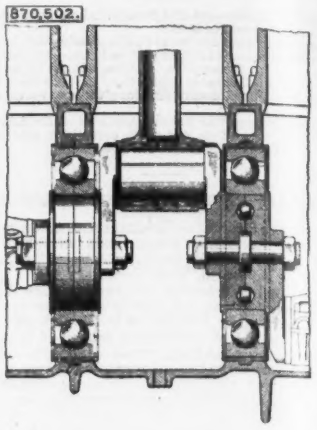


housings. The beam can be caused to rise and fall by means of bell cranks, which are worked by hydraulic cylinders. There are five claims.

870,502. CRANK SHAFT, *T. J. Fay, New York, N.Y., and J. M. Ellsworth, Bernardville, N.J.—Filed April 8th*, 1907.

This invention applies to crank shafts for light motor car engines and the like. The crank shaft is built up and the discs are prevented from slipping on each other by dowels let in as shown. The dowels are really buttons, which do not bottom in the holes, and

870,502.

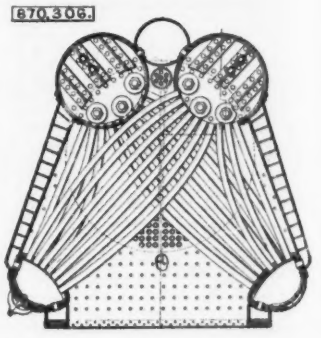


so fit tight when the discs are screwed up. The edges of the discs run in ball bearings. There are twenty-two claims.

870,306. FIRE-BOX FOR LOCOMOTIVE BOILERS, *J. M. McClellan, Everett, Mass.—Filed December 20th*, 1906.

The drawing explains itself. The arrangement shown is combined with a barrel and longitudinal fire flues of the normal kind. There are twenty-four claims.

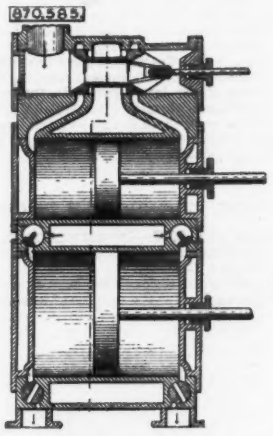
870,306.



870,585. METHOD OF UTILISING WORKING FLUID IN JACKETED ENGINES, *S. A. Reeve, Worcester, Mass., assignor to C. F. Brown, trustee, Reading, Mass.—Filed April 24th*, 1901.

The patentee is a man well known in the United States as an authority on thermodynamics. There are four claims. The third runs as follows:—The process of converting the thermal energy of

870,585.

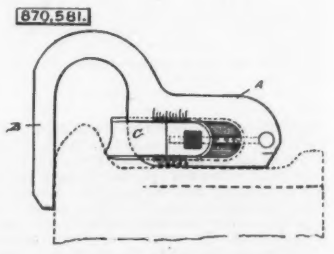


a highly-superheated fluid into mechanical energy which consists in performing mechanical work by expanding the working fluid successively in a plurality of cylinders, exhausting the fluid from the high-pressure cylinder into an intermediate unreheated receiver space, and jacketing the fluid in both high and low-pressure cylinders by means of said exhaust fluid, whereby the high-pressure working fluid is cooled and the low-pressure fluid heated.

870,581. COMBINATION WHEEL AND TIRE GAUGE, *J. E. Omer, Chicago, Ill.—Filed May 7th*, 1906.

The drawing explains itself. The third of four claims runs:—A measuring instrument for measuring the thickness of wheel

870,581.



flanges, comprising a body portion A, a hook B, a slide C, a scale on said body portion, an indicating line on said slide, and a spring for holding said slide in adjusted position.

MECHANICAL POINTS IN CONNECTION WITH STEAM TURBINES.

(By a Correspondent.)

THE feeling of untrustworthiness which for so long was the predominant note in connection with turbine work dies hard, and is still very rampant in many quarters. A veil of secrecy necessarily accompanies the development of such a revolutionary prime mover, and consequently many of the difficulties which occur gain an undue importance in the eyes of those not intimately acquainted with turbine construction. Apart entirely from the question of economical fuel consumption, the success of a prime mover depends on its reliability for continuity of operation. It is natural to expect that mechanical troubles not hitherto experienced should be met with, but it is surprising what a large proportion of the troubles which have been experienced and have contributed to the creation of this feeling are due to causes which are not inherently embodied in the turbine principle. Had the same details and methods been used on reciprocating engines, trouble would have certainly followed. These remarks are not confined to any one type of turbine, or to those constructed in this country. Engineers in all parts of the world are actively engaged in turbine development, and it is very striking how universal the custom is to treat the accessory details as requiring special and novel designs.

In contradiction to this view it may be taken that the details will ultimately become simplified into similar designs to those which have proved themselves on reciprocating engines. In this article some of these points will be considered, and to avoid repetition commencement will be made at the steam inlet, and the other parts will be taken in sequence through the machine.

Steam pipe.—With some of the methods of connection adopted this has proved a fruitful source of cylinder distortion. The longitudinal expansion of the cylinder must be provided for, in addition to that of the steam pipe. The length of pipe connecting to the cylinder should be a bend of sufficient elasticity to take up the expansion without putting any undue stress on the cylinder. The end remote from the cylinder must be securely anchored, so that the rack and strain of a long length of piping is isolated from the cylinder. Anchoring the pipe also prevents vibration being transmitted to the steam range. The high period vibration of a turbine, although of small amplitude, often coincides with the natural period of vibration of the piping, and causes the latter to dance violently. In support of the contention at the commencement, it may be remarked, in passing, that this is precisely what is necessary in connection with reciprocating engines, yet almost every one connected with turbine work has experienced much trouble from neglect of this simple precaution, and it will be noticed that a similar parallel exists in many other cases.

Cylinder.—The usual trouble experienced here is distortion, which may be caused by temperature or external forces. If the steam and exhaust connections are properly made, and the chest containing the governor valve, &c., suitably supported when placed on the side, it resolves itself into a question of design. The horizontal joint is an addition to the problem, but in many respects it is akin to that which has to be faced with large steam engine cylinders. In one respect it has the advantage, for it has no rapid and continuous changes in temperature to withstand. After it is once heated up it remains approximately the temperature of the steam with which it is in contact right through, from inlet to exhaust.

Ribs and branches should be avoided wherever possible, and the barrel retained as a plain cylinder. After rough machining and before finishing, the castings should be annealed at a temperature of about 1000 deg. Fah., to relieve all casting stresses. This is especially important when highly superheated steam is used. Although a turbine can be started up cold without the risks attendant on similar treatment of a reciprocating engine, it is obviously inadvisable to do so unless under urgent necessity. The more gradual and thorough the heating-up process, the less likelihood of distortion, as the flanges and facings will have time to warm up in addition to the thinner barrel metal. The methods of supporting and securing the cylinder for reaction turbines must be carefully designed to prevent hogging. Many a blade strip has occurred through neglect to ensure free longitudinal expansion. The distribution of the non-conducting material used also demands careful consideration, and the horizontal flanges must be well covered. The covering over the flanges must be made removable to allow of lifting the top half of the cylinder, and neglect to replace it, before starting up, has led to disaster. A moment's reflection will make the reason apparent.

The revolving element.—The objects to be attained are rigidity and balance. So long as the deflection does not exceed a certain amount, and accurate workmanship with homogeneity of metal are ensured, rigidity and balance can readily be obtained. The parts can be either forced or shrunk together and secured in various ways. That parts of spindles have worked loose in service emphasises the necessity of special attention being given to providing positive locking arrangements. A good method of construction is that of forcing on with only sufficient forcing allowance to ensure a good fit, in which case a key must be provided to transmit the turning moment. This enables the various parts to be finished and balanced before assembly, which materially facilitates the balancing of the complete spindle, there being no distortion from the forcing.

Couplings.—Most of these troubles have been due to defects in lining up, or insufficient contact surface causing wear and tear, with consequent heating and vibration. It is questionable with some designs how much flexibility in the horizontal direction actually exists when the plant is running on load. The generator shaft should have ample bearing collars to restrict the longitudinal movement, so that driving is the only duty which the coupling has to perform.

Main bearings.—Contrary to natural expectations, little trouble has been experienced here. The troubles which have occurred have been mainly due to defective lubrication. Bearings of the sleeve type are desirable for speeds of 2000 R.P.M. and upwards, but below 2000 R.P.M. solid bearings of cast iron, babbitted, are quite satisfactory. The seat should be spherical, and the shell of ample strength. The two halves of the bearing must be securely bolted together to prevent any springing in the overhung parts. Although water cooling has been provided on very large bearings, it is better to dispense with water cooling, and to supply a sufficient quantity of oil to carry off the heat. The water connections on spherical-seated bearings are liable to leak and give trouble with the oil. The lubrication of bearings will be considered under "Oil Service."

Thrust bearings.—Although the primary purpose of the thrust bearing is to regulate the relative positions of spindle and cylinder, it can, of course, take some load. The single-flow reaction turbine is designed to be balanced and free from end thrust, but the possibilities of an end thrust do exist. When starting up a new machine, the direction and amount of the thrust must be determined, and a balance obtained by adjusting the blading. Unless this end thrust is carefully balanced, the thrust bearing will wear, with consequent trouble at the dummies. The importance of correct balance and thrust adjustment is so great that some further provision than that commonly provided for the purpose would prove a great advantage, especially for repair and overhauling on site.

Oil service.—The conditions to be met are continuity of supply and efficient filtering and cooling arrangements. Practically the universal system is to supply oil under pressure either direct from the pump or from an overhead tank. The advantage of the tank is that it can act as a reserve in case of pump failure, and also be used to flood the bearings before starting up. For moderate sized units the self-contained system, *i.e.*, turbine driving its own pump, is undoubtedly the best, but for extensive stations of large units the independent central system has many advantages. For self-contained sets a small hand pump for flooding the bearings before starting up is a cheap and desirable addition. A small horizontal steam pump is sometimes used for this purpose, in which case it also serves as a standby in case of need. The problem of bearing lubrication on the turbine differs in some important respects from that on a double-acting reciprocating engine. There is no reversal of pressure on the journal, and consequently no knock to be absorbed. In addition to lubricating the bearings the oil has to carry off a much greater quantity of heat than on an engine, for, besides the heat generated in the bearing, heat is conducted along the shaft from those parts in contact with the steam. The quantity of oil required to be passed through a similar bearing per unit of time is much greater than in reciprocating engine work, and provision must be made for a continuous flow through the bearing. Except to ensure the bearings being flooded with oil there is no need for pressure, as the oil is drawn between the journal and bearing in the same manner as with the oil bath in the experiments carried out by Mr. Beauchamp Tower for the Research Committee of the Institution of Mechanical Engineers.

Although the velocities and pressures used in those experiments are not such as are common in turbine work, still much can be learnt by a study of the distribution of pressure in the bearing and the results of the various methods used for feeding in the oil. One highly successful method for solid bearings is as follows:—The top half of the bearing only touches the journal by a narrow strip along the vertical centre line and around the ends of the bearing, leaving a pocket on each side. The strip along the top is to prevent the shaft from rising, and the strips at the ends form the pockets which are used to provide an oil bath. The lower half of the bearing is relieved at the horizontal centre line for a distance corresponding to the pockets in the top half to prevent the journal being nipped. This also serves to feed in the oil. It extends for a small part of the circumference, and is tapered off to the bore of the bearing. The oil inlet is in the top half of the bearing on the downward side considering the direction of rotation of the shaft. The oil is carried round by the shaft and discharged into the pocket on the other side. Grooves are cut through the strips at the ends of this pocket to allow a proportion of the oil to escape and ensure a sufficient circulation. Of course, a quantity of oil escapes all round the bearing, but it is usually necessary to add some grooves in addition. No grooves whatever should be cut in the bottom half of the bearing, as they only allow the oil to escape and materially reduce the load which could otherwise be safely carried. A consideration of the distribution of oil pressures, as recorded in the tests previously mentioned, will make the reason obvious.

The oil leakage, where the shafts pass through the bearing pedestals, has proved a source of complaint. The thin brass scraper rings, which have been largely used to prevent the oil creeping along the shaft, are inadequate. The positive oil-thrower, universally used on enclosed splash and forced lubrication engines, however, usually meets the case, although the fan action of the generator is much greater with turbine-driven sets. This produces a region of low pressure around the pedestal, where the shaft passes out, and induces a current of air to pass through the pedestal so as to suck out the oil. In cases where clearances have been cut fine this point has assumed great importance, owing to oil getting into the generator windings. It is especially difficult to prevent leakage, when, in addition to the natural fan action of the generator, devices are included in the generator design to induce a current of air for ventilating purposes. In such cases the only absolute security is to isolate the end of the pedestal from the suction effect. Except for very small pipes, flanges should be used with metal joint rings. Any other packing material is affected by the oil with consequent leakage. Much of the oil piping is exposed to view, and any slight weeping which would not be of importance on an enclosed engine is highly objectional for the sake of appearance. When the turbine drives the oil pump there is a large choice of the designs which can be employed. There is the ordinary plunger pump with valves, the valveless plunger pump universally used on forced lubrication engines, and several designs of rotary pumps. Each type claims some advantages, but owing to the great success of the valveless pump and the confidence inspired by its wide and extended service, it will naturally take a large share of the turbine work. In view of the success which has attended the simple oil-straining system adopted on forced lubrication engines, the methods used with many turbine installations are very surprising. In some cases a small box, containing several screens of wire gauze or calico, is connected with the delivery side of the pump, and about 10 per cent. of the discharge is by-passed through the strainer. It is claimed that the filtration of this volume is sufficient to keep the whole body of oil in a satisfactory condition. In other designs the oil flows over perforated trays, from the underside of which hang bags made of calico or similar material. The oil, being hot and thin, percolates through and falls into a tank underneath. The upkeep and attention required to keep these bags in a satisfactory condition must be a considerable item. The objection raised to putting the strainer on the pump suction, which is commonly done with forced lubrication engines, is that, should the strainer become clogged, the oil is cut off. One method of avoiding this is to arrange the strainers so that the oil gravitates through them, and in the event of them becoming clogged the oil overflows into the suction chamber. As, however, it is usually impossible to arrange much gravity head, the strainer surface required becomes much greater than where the head due to the suction pump is utilised. That some strainer is absolutely necessary in commercial service experience has amply proved, and if accessibility is provided there is no reason why the system, which has proved successful with the reciprocating engine, should not do equally well on the turbine.

The oil-cooling problem is a very important one, and is much more difficult than is commonly imagined. Temperatures of 120 deg. to 130 deg. Fah. for the oil leaving the bearing are not uncommon. Some engineers advocate 150 deg. to 160 deg. Fah. as being quite safe with suitable oil. The oil to the bearing is usually some 15 deg. to 20 deg. Fah. less than that at which it leaves the bearing. All pipe joints must be metal to metal, and positively locked to prevent leakage, so that designs, on the ordinary condenser lines, with packed glands, are out of the question. Copper coils immersed in a tank of oil, with the cooling water passing through them, are notoriously inefficient, owing to the cooled oil adhering to the outside of the tubes and acting like a blanket. Pumping the oil through the coil with the water outside is a considerable improvement. To obtain the maximum cooling capacity per square foot of tube surface, the counter-flow system should be embodied in the design, and the tank so arranged that the fluid outside the coils is obliged to flow along their whole length and be brought intimately into contact with them. Provision must be made for examination and cleaning, and the more readily this can be done the greater the likelihood of the cooler being kept in an efficient condition. The coils should be well clamped and supported to prevent vibration. Owing to the persistency with which oil permeates any porous metal, special attention must be given to all castings which will contain oil, whether under pressure or otherwise. They should be so designed that no chaplets need be used, and all liability to porous metal must be avoided. Testing under water pressure will locate any leaky spots; and possibly save much trouble and expense later. In some cases oil indicators are fitted on each bearing. Except under special circumstances, this is quite unnecessary, and a pressure gauge connected to a suitable point in the system is all that is required. We consider that the multiplication of safety devices, unless absolutely necessary, does much harm, owing to the distrust they inspire by the suggestion of possible failure.

Governing.—The system of operating the governor valve by means of steam or other working fluid in a relay cylinder, or electrically, has been very popular in turbine work. In view of the great success attending the direct operated governor valve used on high-speed engines, there can be no doubt that this method, which is much simpler, can be equally successful on turbines governed by throttling, and requiring up to 8in. or 10in. diameter valves.

The oscillating gear in conjunction with a steam relay cylinder, commonly used on one type of turbine, certainly overcomes the friction of rest; but, if this is of vital importance, why have not the engine builders been driven to the same solution of the difficulty?

There is no difference in steam consumption, for the results with the oscillating gear follow the straight line law characteristic of throttle governing with a direct connected valve. Supporters of the oscillating gear contend that with a turbine the friction of rest has a greater effect in producing "stickiness," owing to the even turning moment of a turbine, whereas the comparatively uneven turning moment of a reciprocating engine tends to keep the governor and gear continually on the move, although so slightly as to be practically not apparent. However, in order to obtain satisfactory operation when running in parallel, some turbine makers have found it necessary to reduce the travel to the least possible amount, and to increase the periodicity of the oscillations to about 250 per minute, thus reducing the valve beat to a small vibration, so as to tone out the impulses given to the rotating part by the gusts of steam. The trouble probably arose with sets where the rotating parts were unusually light. In view of these facts failure from this point need not be anticipated. That indifferent governing has been experienced with direct operated valves, may probably be accounted for by other reasons. With

the oscillating gear the valve seats itself at each beat, when on light loads, so that both seats must be the same diameter, involving a loose seat ring. If uneven diameters are used "hunting" will result at light loads. An air dashpot is commonly arranged on the valve spindle; but, as the travel is small when the valve is seating, the dashpot is of little service when most needed. To overcome this difficulty an arrangement of joggle links is used by some builders, to vary the lift o the valve with the load, so that the lift is increased as the load decreases. In any case, however, the loose seat ring is a weak point. Also the beating soon wears a facing of considerable width on the seats, and causes leakage should the valve be required to shut the steam right off. This reason has contributed to the undue importance given to the safety governor valve. Engine builders long since found out the impossibility of making, and keeping, a double-seated valve tight with anything wider than a knife edge contact. With a direct-connected valve of the design commonly known as the Belliss type the seats never come into contact except when the governor flies to the extreme outer position, so that the seats keep in good condition. In that design the seats can be made of slightly different diameters, so that a loose seat ring is not required. The shape of the valve and seating also lends itself to a successful design for expansion, especially under superheated steam conditions. The valve should be carried on a small diameter spindle passing through a long bush to prevent it being much out of balance, and to obtain steam tightness with a minimum of friction. No adjustable stuffing-box should be used, as it may be screwed up sufficiently to nip the spindle. In designing the connections care should be taken that no bending moment is put on the valve spindle, as owing to its small diameter it is easily distorted slightly, and then stickiness results. The valve spindle is the only delicate point with the direct-connected governor, but that it can be made absolutely reliable is amply demonstrated by the thousands of sets in successful operation. The connection between valve and governor should be direct, rigid contain few joints, and be as light as possible to reduce inertia. For this reason, rods and rocking shafts of large diameter tubing should be used to obtain rigidity with the minimum of weight. The governor is a detail showing great divergence in design. The elaborate designs, built up of many parts, often defeat the very objects for which they are produced. Here, again, engine builders have evolved by experience simple designs, which are not only much cheaper to make, but wear far longer and give better results under service conditions than more elaborate kinds. Summed up, the engine builders' experience amounts to:—(*a*) Few parts, designed to facilitate accurate workmanship; (*b*) few joints, with ample bearing surfaces; (*c*) plain pins, instead of knife edges; and (*d*) forced lubrication throughout.

It has been found advantageous, with a direct connected valve, to provide a more powerful governor than at first consideration would seem necessary. The cost is very small, as the speed can be kept high. Although the power may never be required, it places all fear of possible trouble from friction out of the question. Compared with a steam relay cylinder and oscillating gear, the direct-connected valve possesses far less possibilities of failure, is adjusted much more easily, and requires less attention in operation. The bearings requiring hand lubrication are very few, while their movement is extremely small.

With a relay cylinder actuated by a fluid, operation depends on the pump. The objection to all relay systems is their tendency to lag or overrun, and also to stick unless kept continually reciprocating. The governor is usually fixed on a reduced speed shaft driven by the main shaft through a worm and wheel. The main shaft has adjustable bearings, but the second shaft is often not made adjustable. Consequently the worm and wheel are not correctly lined up at the pitch lines, with resultant excessive wear and tear. With oscillating governor gear the worm wheel shaft is horizontal, and drives the gear by an excentric or cam on this shaft. The governor is fixed on another vertical shaft driven by bevel wheels or skew gearing from the horizontal shaft. With a direct operating governor gear this second shaft and gear wheels can be dispensed with, and the possibility of trouble with this set of gear wheels will be avoided. When a reduced speed shaft is required to drive a plunger or rotary oil pump there may be some advantages by fixing the governor on this shaft, whether it be horizontal or vertical; but probably with a direct operating gear it will ultimately be fixed on the main shaft. Naturally the desire arises to develop some form of rotary pump suitable for fixing on the main shaft, and so avoid all gearing. This would slightly increase the overall length, but the positive drive and elimination of all gearing would more than compensate for a slight increase in length. The safety governor is mainly a concession to the fear of a possibility which should be practically unknown under service conditions. The consequences of a turbine running away would, of course, be very serious, but there should be no reason to anticipate the failure of the main governor more often than on reciprocating engine sets, and far too much emphasis has been given to this point. Its services are only required as a last means to prevent disaster, and every care should be taken to ensure successful operation under all possible conditions which may arise. For this reason both governor and valve should be entirely independent of any other details, and the governor should be placed on the main shaft, so that no failure of gearing can affect it.

It should be designed so that when it commences to move it will fly to its extreme position on a slight increase of speed and generate ample power to move the gear. Some designs of safety governor valves are operated by a differential steam piston in a vertical cylinder, so proportioned that the valve is supported and held open by steam pressure. The safety governor opens a small valve exhausting the steam from the underside of the piston, so that the valve falls by reason of its weight and the steam pressure which is admitted on the top of the piston. Other designs utilise the main stop valve for the purpose, and they combine the usual hand wheel and spindle for opening the valve, with a steam piston or spring-loaded devices for closing the valve automatically when operated by the safety governor. For reasons already stated this appears to be undesirable. In case of failure both hand and automatic control is lost. The liability of steam relay systems to stick when not kept continually in motion neutralises any advantages of these designs. A valve of the same design as the direct connected main governor valve previously considered, and loaded with a spring or dead weight, and operated with a trip gear from the safety governor, offers less possibilities of failure, and is positive in its action. It can be so designed that before putting the machine on load the valve and gear can be tested by hand in a few seconds, thus ensuring it being in working order. Butterfly safety valves have done good service on engines, but the rapidity with which a turbine gets away makes it desirable absolutely to cut off all steam, and this cannot be done with a valve of the kind.

Exhaust connection.—The conditions are similar to those at the steam inlet. If there is more than a very short length of horizontal piping it is desirable to anchor the bend below the turbine to the foundations. This prevents the expansion in the horizontal piping from exerting a twisting effort on the turbine cylinder. A corrugated copper expansion pipe or wrought iron bellows pipe must be provided between the bend and turbine cylinder to take up the vertical expansion.

Concluding remarks.—It seems almost superfluous to insist on the necessity of positively locking all pins on governor gear, and especially all bolts, nuts, and studs in steam spaces, on valve seats, spindles, &c., yet many shut-downs have occurred through neglect of this point. All castings subjected to superheated steam should be annealed after rough machining and before finishing, otherwise permanent distortion will often occur when put in service. Special attention must be given in designing steam chests, valves, &c., to obtain forms which will expand evenly and retain their shape. It may be argued that many troubles have been experienced which are confined entirely to the turbine, but, considering the vast amount of pioneer work which has been successfully accomplished, and the world-wide development which is going forward, it is certain that the difficulties will be surmounted.

THE ALWEN WATER SCHEME FOR BIRKENHEAD.

THE Corporation of Birkenhead introduced into Parliament last session a Bill to authorise them to construct three reservoirs in the neighbourhood of Cerrig-y-Druidion, in the county of Denbigh, for the purpose of supplying their district with water, namely, the Alwen Reservoir, the Brenig Reservoir, and the Glan Alwen Reservoir. It was contemplated that these reservoirs would be constructed at different times, extending over a considerable number of years, and that the yield from them would be furnished in three instalments, which would be provided concurrently with the construction of the several reservoirs—that is to say, a first instalment of

7,000,000	gallons a day after the construction of the Alwen Reservoir; a second instalment of
7,000,000	gallons after the construction of the Brenig Reservoir; and a a third instalment of about
4,500,000	gallons after the construction of the Glan Alwen Reservoir;
Total ...	18,500,000

and that this would be the aggregate net quantity of water available for supply purposes after the proper amount of compensation water to the rivers Alwen and Brenig had been provided. The estimated cost of the total scheme was about £1,750,000, of which sum about £800,000 was the estimated cost of the Alwen scheme; that is to say, the construction of the Alwen Reservoir, and works with the necessary filter beds, the pipe line for conveyence of seven million gallons of water a day to Birkenhead, all necessary balancing tanks and a service reservoir, and the pipe line covering a distance of about forty-two miles.

The Bill was first introduced into the House of Lords, and was referred to a Committee presided over by Lord Newton. The proposal that three reservoirs should be constructed was very strongly opposed, and eventually Mr. Balfour Browne, the leading counsel for the Corporation of Birkenhead, offered to abandon the Glan Alwen Reservoir if the Committee were of opinion that the Corporation of Birkenhead, in suggesting its construction, were looking farther ahead than was reasonably necessary. The Committee expressed the opinion that this was the case, and the third reservoir was therefore abandoned.

With this modification the Bill, so far as the proposed works were concerned, passed the House of Lords and the House of Commons practically in the form in which it was introduced into Parliament, but the rate of compensation water was increased from one-quarter to one-third of the yield of the streams, which was, of course, a very serious matter for the promoters.

As before stated, the Bill was very strongly opposed in both Houses, the principal opponents being the Dee Conservancy Board, the River Dee Fishery Board, the Corporation of the City of Chester, the Cheshire County Council, the Co poration of Liverpool, and certain landowners.

One of the most important oppositions perhaps was that of the City of Chester, but an agreement was ultimately arrived at between the two Corporations by which Chester, on giving certain notice, may obtain a supply. At the present time the right to supply the inhabitants of Chester is vested in the Chester Waterworks Company. A limit of time is imposed by the Act for the giving of such notice, namely, any time within ten years from the commencement of a supply to Birkenhead from the new works.

The opposition of the Dee Conservancy Board was also a serious matter. The Conservancy alleged that great damage would be caused to the estuary of the river Dee and the navigation by reason of the proposed abstraction of water from the rivers Alwen and Brenig. Upon the report, however, of an independent eminent engineer, appointed by the Board of Trade, the opposition was eventually settled on terms approved by both parties. The opposition of the Dee Fishery Board was also eventually settled between the Corporation and the Board.

Several local authorities and companies opposed the Bill with a view to obtaining the insertion of a clause compelling the Corporation of Birkenhead to supply them with water at fixed rates, which is a clause which has been inserted in practically all recent Water Acts. The clause which the Corporation had proposed to insert as regards the supply to other bodies was a permissive clause enabling them to supply upon such terms as might be agreed between themselves and the body to be supplied, and eventually a permissive clause of this sort was allowed by Parliament; the supply, however, being limited to districts, any part of which are situate within five miles of the aqueduct authorised by the Act, and the price to be charged by the Corporation is to be such sum per 1000 gallons as shall not exceed by more than 10 per cent., the average sum per 1000 gallons payable in Birkenhead. It may be stated that before the Bill came into Committee in the House of Lords the Corporation had entered into arrangements with many Welsh local authorities for the supply of water at agreed rates in the districts of those authorities. The landowners were all settled with eventually on terms mutually satisfactory to both sides, and the Corporation brought the Bill into the Second House, the House of Commons, without a single landowner in opposition.

Certain arrangements, which are believed to be of a novel character, are authorised by the Bill—these are arrangements whereby the Corporation, instead of purchasing the gathering grounds surrounding the reservoirs, have in several cases made agreements with the owners whereby the Corporation will purchase from the owner such part of his land as may be necessary for the proposed reservoir, together with a fringe surrounding the same, leaving the owner with almost unaltered rights over such part of his adjoining land as forms part of a watershed. These lands are in every case at present used as grouse moors and for sheep grazing, and the district is extremely sparsely populated.

Under the arrangements the Corporation are empowered to drain the land not acquired by them, and to carry out any works which may be necessary to prevent pollution of the water flowing to or contained in the reservoir, and the owner is not to build on his land, or, without the consent of the Corporation, to mine or to divert the water or to do anything which would cause or contribute to the causing of the pollution of the water, but the owner preserves his sporting rights, and is also given certain sporting and fishing rights over the land acquired from him for the reservoir. In some cases, however, the Corporation will buy the whole of the lands from certain of the owners within the limits of deviation.

The Corporation of Birkenhead are taking steps to put the new Act into operation, but some time must necessarily elapse before the works can be commenced. A period of ten years is given by the Act for the construction of the Alwen Reservoir. The original estimate of about £1,750,000 for the complete scheme of three reservoirs was, by the abandonment of the Glan Alwen Reservoir, reduced to £1,340,000. A period of sixty years is given by the Act for the repayment of the money borrowed by the Corporation, but the creation of a sinking fund is suspended for ten years.

THE HUMBER FISHING COAL CONTRACTS.

A SERIOUS crisis, such as was never known in connection with the placing of the coal contracts for South Yorkshire steam coal for the large Humber steam trawling companies, has arisen. It is computed that something like 700,000 tons are consumed at Grimsby and Hull respectively every year. These contracts have assumed remarkable extensions of late years, and so far as the South Yorkshire coalowners are concerned, rank as scarcely second to those given out by railway companies. As a rule the owners of the trawlers favour South Yorkshire "hards" on account of the limited coaling accommodation provided on the vessels. Coalowners contend that shippers can procure 20 per cent. better results than from any other class of fuel. The contracts, which are yearly ones, have usually been placed with little trouble. The existing contracts are at the rate of 9s. 6d. per ton of 20 cwt. The Associated South Yorkshire Coal Owners have tendered at 12s. per ton for not less than twelve months, the price asked from the North-Eastern Railway Company, and the price paid by the Midland, Great Eastern, and Great Northern Railway Companies until the close of June next. The demand for an advance of 2s. 6d. per ton is creating considerable interest at both the ports. At an important private meeting of the Grimsby trawl owners on 17th inst. the matter was considered, and it was unanimously resolved that no contracts be made at present, and that a meeting be held early in January, when a final decision will be come to as to dealing with the matter. So far as Grimsby is concerned, it was suggested that coal might be brought from the North of England for North Sea fishers, and Iceland boats might call at the Tyne to coal. It is also contended that coal might be sent by lighters from Tyneside to Grimsby and re-shipped at a cheaper rate than the cost this year. The suggestions brought forward to combat the advance at Hull are that 25 per cent. of the trawlers should be laid up at Fleetwood and other East Coast fishing ports, where coal can be purchased cheaper than at Hull. Another suggestion is that the large Iceland trawlers should call at Shields, Blythe or Hartlepool for North of England coal. Inquiries made at Barnsley market on 18th inst. showed that local coalowners were very little moved by the threats. South Yorkshire owners point out that for at least nine months the various companies have had their coal at 2s. 6d. per ton less than the market price, for in March the associated owners passed a general resolution not to tender for South Yorkshire hards at less than 12s. per ton before the close of June. It is also pointed out that the threat to purchase North of England coal at cheaper rates is absurd, as the Durham and Northumberland collieries are quoting the North-Eastern a larger advance for next year's contracts than South Yorkshire owners are showing. It is also pointed out that some of the Grimsby companies were in the market for extra supplies, and paid in some instances over 12s. per ton.

THE PUY DE DOME ADHESION RAILWAY.

OWING to the regularly increasing number of tourists to the Puy de Dôme, a scheme for connecting the summit with Clermont Ferrand was for a long time under consideration, but the technical and financial difficulties seemed insurmountable. As the summit is 3100ft. above the town, and the nature of the ground unsatisfactory, a regular service of trains on an ordinary track, a rack railway, or a funicular, was considered to be impossible, as with the former sufficient adhesion could not be obtained, and with the two latter the expense of construction and maintenance, especially towards the summit, would have been too great.

The Puy de Dôme is of volcanic origin, and consists for the greater part of a soft earthy trachyte, sometimes called "domite," after the name of the mountain, and it is an exceedingly difficult matter to keep this "domite" off the track, especially during thunderstorms and when the snow melts. The wind here is also very severe, and frequently attains a velocity of over seventy miles an hour.

In view of these difficulties, M. Claret, the concessionaire for the railway from Clermont Ferrand to the Puy de Dôme—Fig. 1—decided to adopt a special system, and to use ordinary steam locomotives with a supplementary adhesion gear consisting of horizontal wheels acting on a centre rail. M. Claret, to whom France owes her first important electric tramway, had experimented with this system in 1890, and successfully adopted it on the electric tramway which he built in 1904 at La Bourboule, to the designs of M. Hanscotte, engineer of the Compagnie de Fives-Lille. The excellent results then obtained decided M. Claret to construct the Puy de Dôme railway on the same principle, using, however, steam instead of electricity as his motive power.

The idea of adhesion by horizontal wheels is an old one, having first been used by the English engineer Fell in 1863 and 1864, followed by its use in 1865 on a contractor's line with a gradient of 1 in 12½ in connection with the construction of the Mount Cenis Tunnel.

The results, however, were unsatisfactory, and the system was abandoned when Riggenbach invented the "Rack" railway, first used in 1870 on the Witznau Righi Railway on a gradient of 1 in 4, but M. Hanscotte's developments on the La Bourboule Electric Tramways, and later on the Puy de Dôme, have once more brought the horizontal adhesion system into notice.

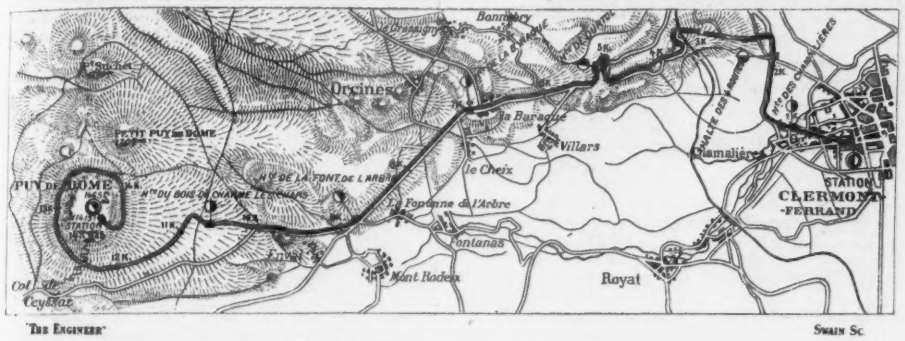


FIG. 1—ROUTE OF THE PUY DE DOME RAILWAY

By using the centre rail, gradients of 1 in 8½ may be climbed; derailing, it is claimed, is impossible, and curves can be considerably shortened. The centre rail itself can be dispensed with for lengths of a few yards at cross-over points or level crossings.

The price is stated to be from 6s. to 7s. per yard, instead of 22s. to 30s., which is approximately the cost of laying down a rack railway.

On the Puy de Dôme Railway the altitude increases by 3100ft. in the first 9·26 miles, the maximum gradients being 1 in 8½, and the centre rail, though only fixed where the gradients exceed 1 in 17, is 9400 yards long, being over half the total length of the line. On the last 4700 yards the gradient is a constant one of 1 in 8½—Fig. 2—and there are 134 curves in all, with radii varying from 45 to 2200 yards. Metre gauge is used, with steel rails of the Vignoles type weighing 50 lb. per yard, and the track, Fig. 6, only differs from the ordinary by the addition of a centre rail mounted on brackets, which are securely bolted to the sleepers. This rail, which is of the double-headed type, weighs 54 lb. per yard, and projects 7in. above the level of the track. It is tapered off where interrupted at level crossings, so as to ensure smooth engagement and disengagement of the horizontal wheels, whilst the flexibility of the controlling mechanism permits of various sizes and shapes being used to suit local conditions.

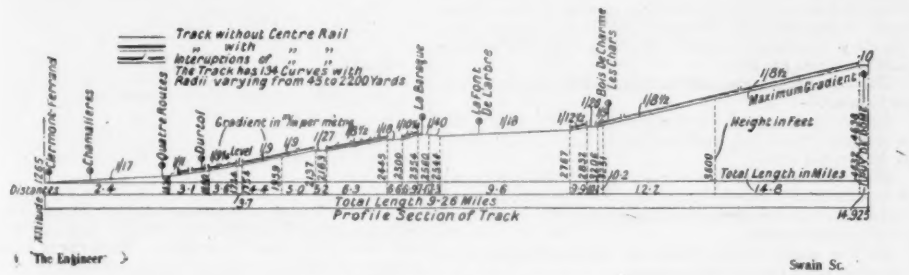


FIG. 2—PROFILE OF THE RAILWAY

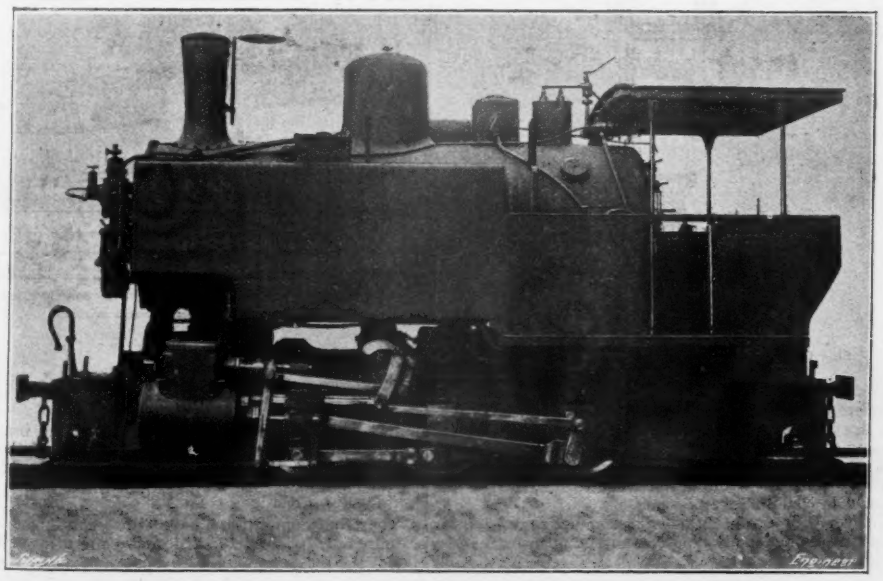


FIG. 3—LOCOMOTIVE USED ON THE PUY DU DOME RAILWAY

sufficient to carry the train over the breaks in the centre rail, which are shown in some of the views on page 645. As these interruptions generally occur where there is little or no gradient, and, as a rule, are short, it happens in most cases that either the front or rear sets of horizontal wheels, which are fixed at the extreme ends of the engines—14ft. centre to centre—are in operation. The present rolling stock consists of five steam locomotives, twelve passenger carriages, and one luggage van, whose width over all in no case exceeds 8ft., the height above the rails being 12ft. 6in. for the engines and 11ft. for the carriages.

The engines—Figs. 3, 4, and 5—have outside cylinders 16½in. diameter with 20½in. stroke, and six-coupled wheels, and are practically of the ordinary tank type, with the exception of the horizontal wheels and their accessories for gripping the centre rail. The driving

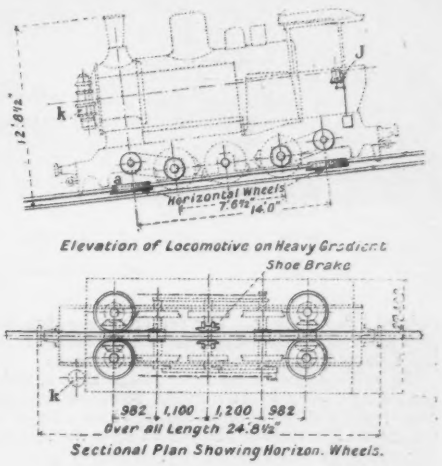


FIG. 4—ELEVATION AND PLAN OF ENGINE

wheels are 2ft. 11$^{7}/_{16}$in. diameter, and the horizontal wheels 2ft. 8½in., and the pressure of the four horizontal wheels on the centre rail varies, it is said, from 0 to 50 tons. The weight of the engine alone is 23 tons, and the supplementary gear five tons, making a total of 28 tons. In full working order the weight is given as 33 tons. The boiler has a grate area of 14¾ square feet, and a total heating surface of 774 square feet; the working pressure is 200 lb. per square inch.

As will be shown later, the pressure of the horizontal wheels on the centre rail can be regulated according to circumstances, and, once regulated, will vary automatically with the gradient. The engine is always in front of the train, chimney first when mounting, and cab first when descending. In this latter case the driver has an uninterrupted view of the track. The boiler has two water gauges, one showing the level when climbing, and the other when descending, and the only precaution taken is to keep the crown of the fire-box covered with water.

The horizontal wheels, which are shown in Figs. 7 and 8, are fixed at the extreme ends of the locomotive, and are mounted on vertical spindles *b b* revolving in the bearings *c* and *d* fixed to the casting *e e*, which is free to

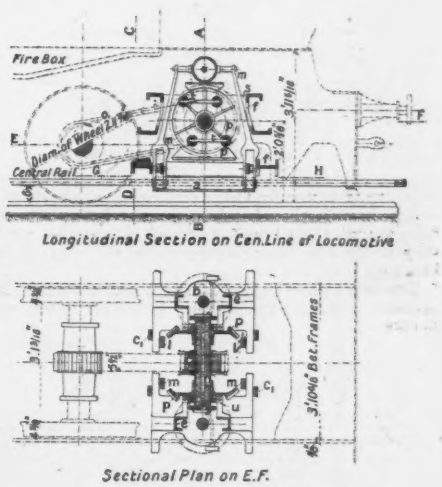


FIG. 5—DETAILS OF ADHESION GEAR

slide transversely to the track in the guides *f f f f*. The upper face of each hub is so machined as to act as an oil bath for lubricating the lower bearings of the vertical spindles, and any oil which may creep out is retained by a flange projecting inward from the rims of the wheels, as shown at *g* and *h* in Fig. 7.

A two-stage air-compressor K of the "Fives-Lille" type charges a receiver on the engine, which in its turn supplies air for the continuous air brake—Fig. 10—and also to the cylinder *i*, which causes the horizontal wheel to press on the centre rail. The admission of the air to the cylinder is controlled by an automatic valve—Fig. 9—according to the gradient. The cylinder *i*—Fig. 7—is carried on the castings *e e* by means of the four levers *l l*, *m m*, of which the top ends of the latter are joined directly on to the cylinder casting, whilst the tops of the two former are joined by radius links to the crosshead of the air piston. The lower ends of these four levers are forked, and are joined on to the castings *e e* by means of lugs *n n*

at the level of the centre line of the centre rail. The fulcrums of the levers are formed by pins in a swinging link, so allowing a flexibility of the whole system, which ensures an equal pressure of the horizontal wheels on each side of the rail, irrespective of any irregularity in the same, or of the swaying of the engine.

Each pair of horizontal wheels is driven from the nearest axle by a link chain belt o—Fig. 5—which is

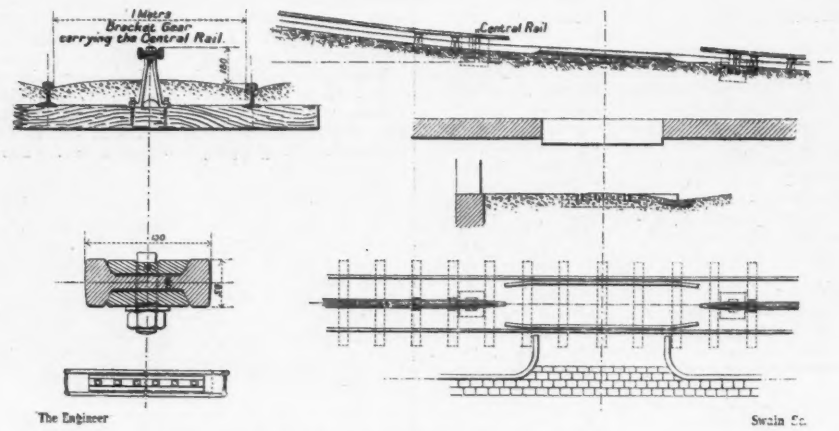


Fig. 6—DETAILS OF THE PERMANENT WAY

claimed to be noiseless. This belt drives the chain wheel q—Fig. 5 and 7—which communicates its motion through the bevel gearing p p_1 to the horizontal wheels.

The cut wheels q, being loose on the shaft r, which is carried by the brackets s s on the frame of the engine, drive the cut helical bevel wheels p, which are also loose on the shaft r, through the jointed links t. The bevels

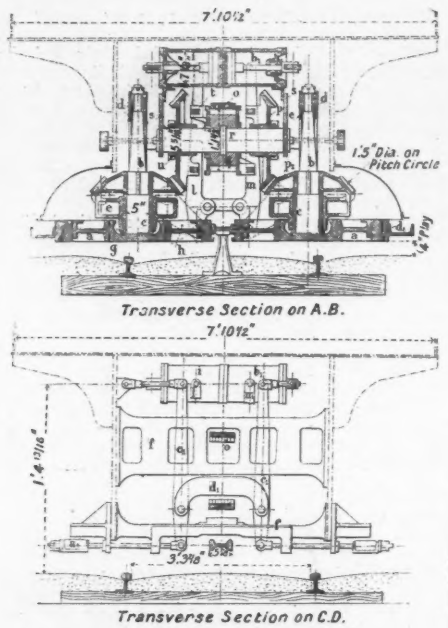


Fig. 7—GEAR OF ADHESION WHEELS

p l move transversely to the frame with the castings e e, and, to keep the bevels p in proper mesh, the latter have collars u on their bosses enclosed in straps—in which they are free to revolve—attached to the castings e e by brackets.

The controlling gear J—Figs. 4 and 9—which automatically regulates the pressure in the air cylinders, and

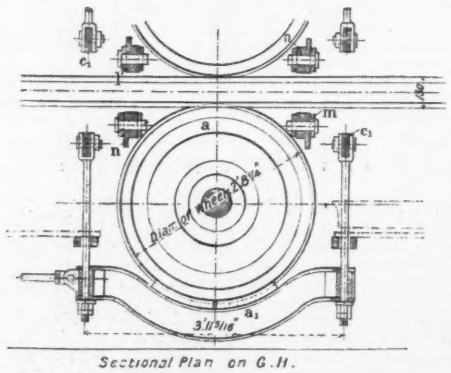


Fig. 3—ADHESION WHEEL BRAKE

therefore that of the horizontal wheels on the centre rail according to the gradient, consists of a valve-box—Fig. 9—fixed to the tender, in which there is a sliding valve connected to a spindle in such a manner that a diaphragm always tends to close the pressure inlet port. When the engine inclines one way or the other, the pendulum weight y will lift the valve through the action of a lever, so admitting compressed air to the adhesion cylinder in larger or smaller quantities according to the gradient. The valve is so arranged that, if the pressure in the cylinder drops through a leak or other cause, it will at once open to allow of more compressed air being admitted to replace the loss. The whole of the horizontal wheel gear is encased in easily removable covers, is quite accessible for lubricating purposes, and can be readily dismounted.

If the track were absolutely straight, with a central rail exactly central and of the same thickness throughout, the horizontal gear would work without any transverse movement, but as these conditions cannot be realised in practice, especially on curves, the bevel wheels p are free to move along the shaft r. As this movement only occurs when the wheels are revolving, the friction due to this cause is a negligible quantity, as also is that of the ends of the coupling links t in their respective gear-wheels p and q, and that of the castings e due to their sliding on the guides f.

The advantages claimed for the horizontal wheels are as follows:—

(1) The pressure of the wheels against the centre rail is independent of any wear on the treads of the wheels or on the rail itself.

(2) The pressure of the wheels against the centre rail is automatically adjusted according to the gradient, and can further be modified to suit the state of the rail and weight of the train.

(3) The axles of the wheels are automatically maintained in their respective positions.

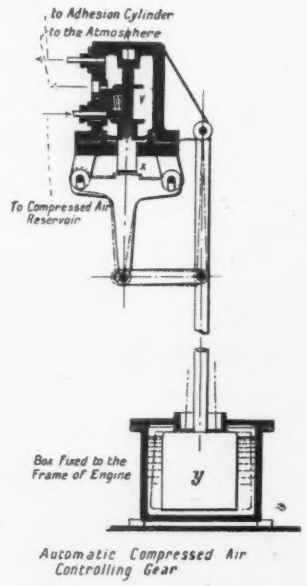


Fig. 9—AUTOMATIC AIR-CONTROLLING GEAR

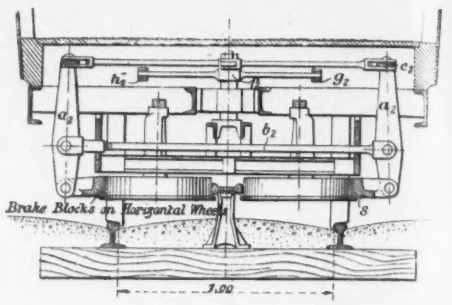
(4) The transverse movement of the wheels does not interfere with their property of supplementary adhesion, nor does it oppose any resistance of importance when passing a curve, as the horizontal gear follows all curves and irregularities of the centre rail quite freely, and without any tendency to disturb the centre rail, though this latter is in constant compression.

(5) On curves of short radius the horizontal wheels assist in guiding the locomotive, and in all cases act as a safeguard against derailment.

Special attention has been paid to braking. The engine is fitted with (1) a hand brake on the vertical wheels; (2) a continuous air brake acting simultaneously on all the vertical and horizontal wheels; (3) a safety "shoe" brake acting on both sides of the centre rail; and (4) the engine can be reversed.

The brake mechanism is of the ordinary type, except on the horizontal wheels. These are fitted with a continuous air brake applied by means of an air cylinder through the connecting links to the levers ci ci—Fig. 7—which are coupled in pairs by the swing links, and thence by adjustable channel bars, curved to the radii of the wheels, to which brake shoes a i are attached—Figs. 5, 8, and 12. The other parts of the brake mechanism, compressor, container, and regulator, serve both sets of wheels—the air cylinder is a duplicate of that operating the brakes of the vertical wheels—and the continuous brake is controlled by a single valve as in ordinary practice. Owing to the pressure of the horizontal wheels being equal on both sides of the centre rail, there is no tendency for the latter to be thrown out of line, and an important safety brake is thus assured when descending. When interruptions occur in the centre rail, the pressure of air in the cylinder i—Fig. 7—causes the horizontal wheels to approach each other until the piston brings up against the cylinder cover, but the brake action still continues on the wheels, and is of assistance in bringing the train to a standstill.

The carriages used are of the ordinary closed passenger type, and will carry forty people—thirty sitting and ten



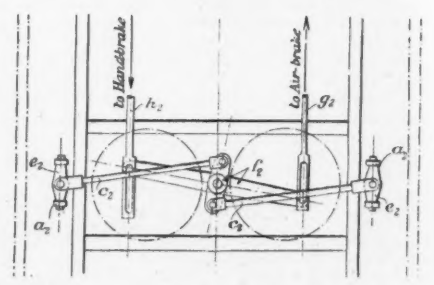


Fig. 10—CONTINUOUS BRAKE MECHANISM

standing. The open, or summer, cars will seat forty, and both are similar to those in general use on tramways with the exception of the brakes. Each car is fitted with a bogie, on which are mounted a pair of horizontal wheels—Fig. 11—running on the centre rail, which are used for braking purposes only.

They are held against the rail by springs, so that their flanges may afford a safeguard against derailment, for, as stated elsewhere, the wind on the higher levels of the Puy de Dôme is at times strong enough to overturn an ordinary carriage. The gradients being so long and heavy, each carriage is provided with an exceptionally powerful brake equipment fitted with (1) an air-pressure gauge; (2) a controlling valve for the continuous air brake on both vertical and horizontal wheels, so that the brakes will be applied automatically should the couplings break; and (3) a hand emergency brake acting on the horizontal wheels, so that for ordinary service conditions such an equipment on the rear carriage should provide an

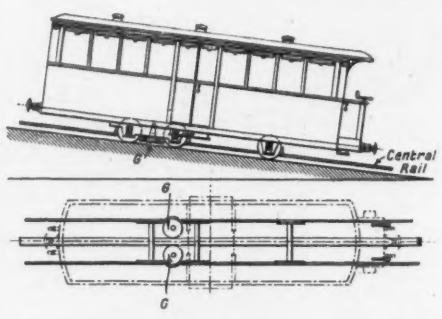


Fig. 11—DIAGRAM OF A CARRIAGE

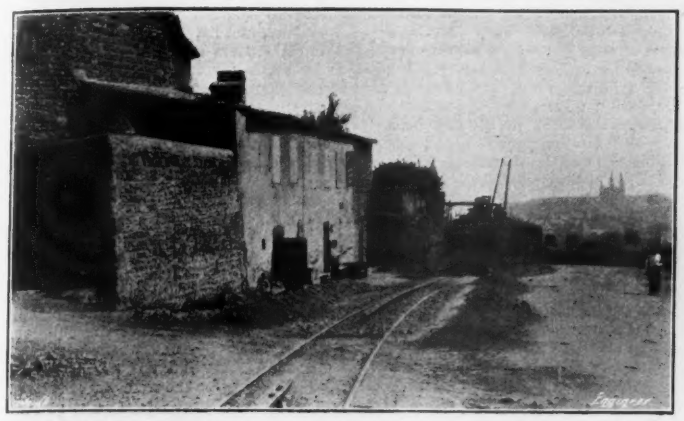
ample margin of safety. The action of the brakes on the horizontal wheels is identical with that of the locomotive, except that the power is supplied by the continuous brake mechanism instead of through a separate air cylinder.

The rod connecting with this continuous brake mechanism, g_2, Fig. 10, and that connecting with the hand brake h_2 are coupled to opposite ends of the four-armed lever f_2, which is pivoted on the bogie pin. From the ends of the short arms the rods c_2 control the crossheads e_2, which during the run operate the double levers a_2, whose lower ends carry the brake shoes. The fulcrum rod b_2 allows the wheels to adjust themselves to slight deviations of the centre rail, whilst maintaining an equal pressure on both sides of same.

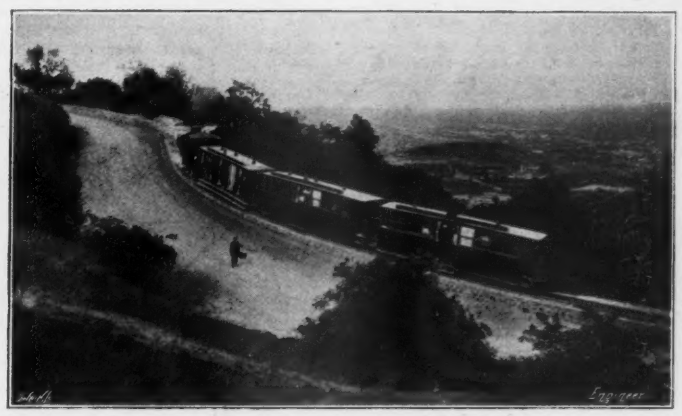
It may be interesting to note how the adhesion necessary for hauling a train under the most unfavourable conditions, viz., with three fully loaded carriages up an incline of 1 in 8½ round curves of 70 yards radius, and

THE PUY DE DOME ADHESION RAILWAY

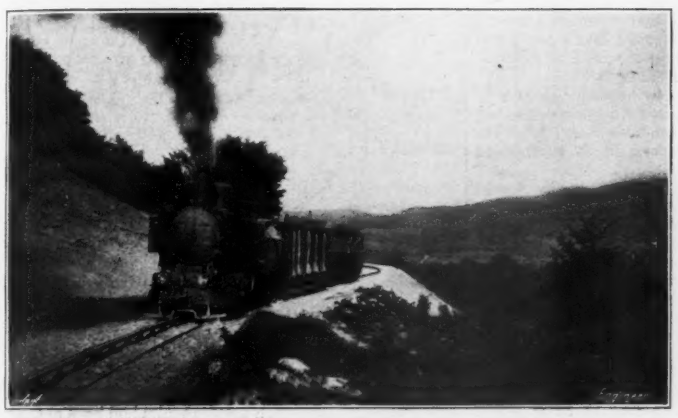
(For description see page 643)



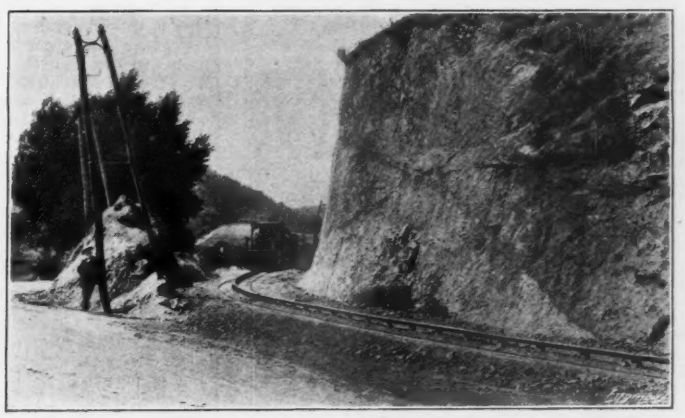
A LEVEL CROSSING



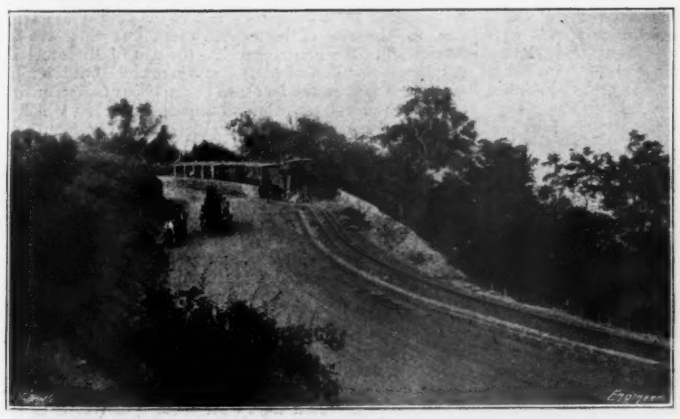
ASCENDING THE GRAND TOURNANT



ON THE SIDE OF THE PUY DE DOME



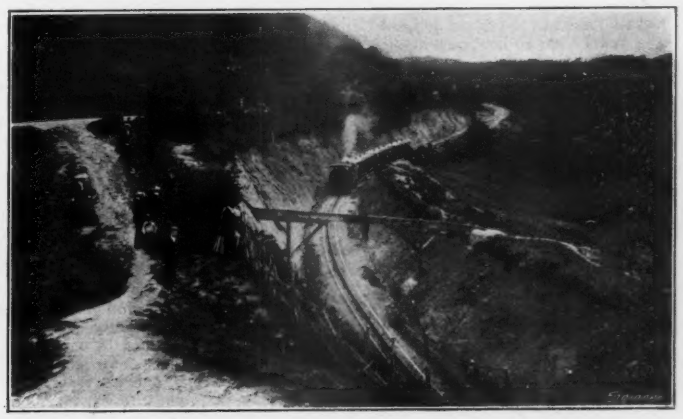
TRAIN ON A CURVE OF 40 METRES



LE GRAND TOURNANT

TRAIN LEAVING QUATRE-ROUTES STATION

AT THE GRAND ROCHER



A HEAVY BANK—11 mm. PER METRE

with a minimum coefficient of adhesion of $\frac{1}{11}$ has been calculated.

Average weight of locomotive	32 tons
Weight of three carriages fully loaded ...	27 ,,
Total weight of train	59 ,,
Total pressure of four horizontal wheels against centre rail	50 ,,
Corresponding air pressure in the adhesion cylinder	110 lb. sq. in.
Total load on the three rails	82 tons
Total adhesion of the locomotive $82 \times \frac{1}{11} =$	7·454 tons
Resistance of the locomotive due to gravity on a gradient of 1 in $8\frac{1}{2} = 263·5$ lb. per ton $= 118 \times 32$ tons ... =	3·776 tons
Resistance of carriage per ton due to gravity ... ... =	263·53 lb.
Resistance of carriage per ton due to friction on curves = 17·61 lb. ... =	281·14 lb.
Total resistance of carriage $281·14 = 125 \times 27$ tons ... ... =	3·375 tons
Total resistance of train = 3·776 + 3·375 =	7·151 tons
Excess of adhesion with a coefficient of $\frac{1}{11}$ =	303 tons

The maximum pressure of 82 tons on the three rails, which is at the driver's disposal for climbing, can also be used for braking purposes when descending, if the engine is reversed, and, in addition, a brake pressure of 14 tons can be put on the horizontal wheels, so that 82 + 14, or a total of 96 tons, can be applied to the three rails for braking purposes.

Isolating valves are provided so that one set of horizontal wheels only can be used should any accident happen to the other set, or if favourable conditions of weather or load require the use of one set only.

Some interesting trials have recently been conducted between Clermont Ferrand and La Baraque—a plan and

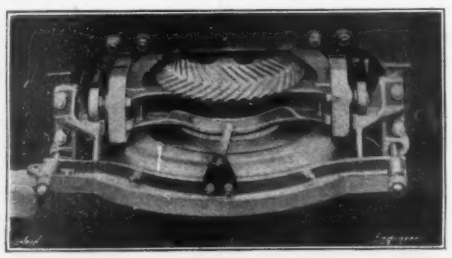


Fig. 12—VIEW OF HORIZONTAL WHEEL

section of the track being shown in Figs. 1 and 2—on a track $4\frac{1}{2}$ miles long, including gradients of 1 in $8\frac{1}{2}$, and curves of 45 yards radius.

The train consisted of a locomotive and three trucks loaded with 2·8 tons of sand—representing the weight of passengers—and the following speeds were attained:—

18·75	miles an hour	on a gradient of	1 in	33·5
15·0	,,	,,	1 in	16·75
9·3	,,	,,	1 in	11·18
6·8	,,	,,	1 in	$8\frac{1}{2}$

The automatic controlling gear gave the same speeds descending as ascending, and experiments without this apparatus showed that by using the continuous air brake, or reversing the engine only, the speed could be kept as low as 12·25 miles an hour.

It is stated that during these trials the lubricating oil did not creep on to the treads of the wheels or spread on to the rails, and that the engine, in spite of its short wheel base, did not rock or jump owing to the influence of the horizontal wheels. Another advantage claimed for the Hanscotte gear is that it can be applied to many types of locomotives; the Southern Railway of France, for instance, has used it with most satisfactory results on some old locomotives to run on an existing line to which a centre rail has been added.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AT an ordinary general meeting of the Institution of Mechanical Engineers, which was held last Friday evening at the Institution's buildings in Storey's-gate, a very interesting and practical paper was read by Dr. H. T. Ashton, of the Royal Small Arms Factory, Enfield Lock, entitled "Notes on the Manufacture and Upkeep of Milling Cutters." There was a large gathering of members present, and the President occupied the chair. After the formal business had been transacted, and before calling upon the author to read his paper, the President—all the members standing—referred to the loss they had sustained in the death of Lord Kelvin, who had for many years been an honorary member of the Institution. In the course of his few remarks the President referred to the great scientist as having done more in the interests of engineering than any other man.

Dr. Ashton then read his paper, which we reproduce *in extenso* on page 660 of this issue. At the request of the President the discussion was opened by Mr. Hughes, of Horwich. From the general tone of his remarks he appeared to be in agreement with practically everything the author had said on the subject. He thought the paper covered all the difficulties usually encountered in the manufacture of milling cutters, but there were one or two points in the paper which did not appear quite clear to him, and on these he asked for information. One of the points was the use of powdered charcoal in annealing the steel. He did not exactly know what the author meant. The cutters were put in this and heated for from $2\frac{3}{4}$ to 3 hours, and it appeared to him that they would be case-hardened. Later on in the paper the author had given details with regard to air hardening, stating that a current of cold damp air was blown on to the cutter and gave a maximum cooling effect. When the air method was employed at the Horwich works it was their custom to have the air as dry as possible. But his experience was not the same as the author's, for he had found that this treatment was not good. It had, in fact, been abandoned there, because of the oxidation it caused. Mr. Hughes further asked the author to extend his remarks on what he had found to be the best angle for helical cutter teeth, and also the pitch; this, he thought, could be easily done, because in another paragraph in the paper the author had stated that all the pitches had been standardised. He agreed with the author's remarks that high-speed steel had not been so successful for milling cutters as one would have expected. Why, he could not say. It might, he said, be due to the design of the tool, or the machine, or to the material, perhaps even to the design of the work on which the tool was being used. But whatever it was the fact remained as stated. In the past it had been the usual practice with ordinary cutters to rough out the work and finish it with the same tool. Mr. Hughes suggested that with the use of high-speed steel, that it might be better and more economical to rough the job out first, and finish it afterwards, presumably with another cutter. In conclusion, he remarked that the heating was the most important point with high-speed steel, and was worthy of the greatest attention. He felt sure that those with experience of air hardening would confirm his statements that oxidation took place immediately, and that a flake formed. He had found that the material was never good before grinding; sometimes it was not good till it had been ground twice, and he had known cases where good results were not obtained till after the third grinding. There appeared to be a soft surface, which was difficult to remove. He added that he would leave the question of the speed of feeding alone, as it had so recently been fully dealt with in THE ENGINEER.

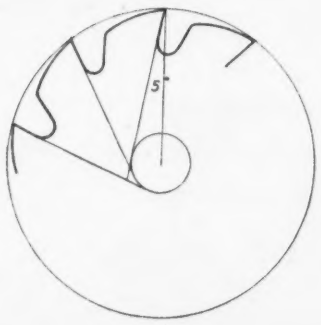
Mr. Donaldson, of Woolwich, commented on the fact that it was unusual to have so many "trade secrets" introduced into a paper as were to be found here, and expressed the wish that the example would be followed in subsequent contributions. Dealing with the paper and the conclusions which were to be deduced from it, he commented on the fact that many engineers had thought that because a steel had been called a "high-speed steel" it should be unsuccessful at load speed and light loads, and this fallacy, he was pleased to see, had been completely exploded by the author. He quoted instances where the length of life of a tool was particularly desirable; and the length of life, as had been shown by the author, was obtainable with the use of high-speed steel. He believed that many of those present would be astounded to gather from the paper that with a cheaper quality of labour a higher quality of work was obtained, a condition he attributed to the intellectual consideration of the problems involved.

Mr. Archibald Bruce also commented on the application of pure science to this subject, and considered it to have been distinctly advantageous. Referring to the author's remarks on the speed and feed of cutters, Mr. Bruce considered that the machine itself was almost as important a factor as the nature of the work upon which the cut is taken and the finish required. He had visited shops both in this country and the United States, and had frequently heard the machines making great noises, which clearly showed that they were not altogether suitable for the work they had to do. On the introduction of high-speed work on lathes and drills the machines were altered in design to suit the new conditions of work, and he considered that in milling machines also the machines themselves should be designed to suit the tool which was to be employed. He noticed that in many instances the author had introduced the word sharpening into the paper, which term, he observed, should be differentiated from grinding; it was quite possible to grind without sharpening. Lastly, he drew attention to what he called the remarkable figures relating to the life of milling cutters, which are given in the last paragraph of the paper.

The next speaker, Mr. O. H. Roberts, of Woolwich, dealt at some length with the question as to whether it pays to make special formed cutters, and his decision appeared to be that where there was much repetition work to be undertaken, the special cutter was not only profitable, but desirable. In certain cases it paid best, he said, to make cutters from ordinary steel. He had recently had an opportunity of going into this matter by comparing three cutters made respectively from ordinary carbon steel, crucible cast steel, and high-speed steel. Which kind it was advisable to use depended upon the class of work in hand. He had found that a ratio existed between the three in the proportion of 1, 2, 3, but he did not make the meaning of this ratio very clear—presumably it referred to cost. He agreed with and emphasised the remarks of the author concerning the desirability of makers supplying the steel satisfactorily annealed, and further agreed with him that this was by no means the universal practice of the makers. This was an eminently important factor, and should receive more careful consideration than hitherto. He quoted cases where the steel, on arriving at the works, had dropped to pieces, and he also told the meeting that in some instances, when the metal had been chipped round with a chisel, the bar had split longitudinally, and this, he believed, was not of infrequent occurrence.

Mr. King, of the Great Western Railway's Works at Swindon, agreed with the author's enunciation of the properties of high-speed steel, and added to them another, for he pointed out that unlike ordinary lathe tools, it had the property of withstanding shock. In one railway shop at Swindon where this material was in use the output had been doubled. Speaking of the hardening furnace, as described in the paper, he said that a similar one had been in use for some time at Swindon, but it had two ovens, one above the other, with which a gradation of temperature was obtained. He regarded the Fery radiation pyrometer as more pleasing than valuable. It showed only the temperature of the spot of the furnace observed, and it did not follow that the whole furnace and its contents were at the same temperature. He considered the Callendar instrument better, but even here the mass of hot material had to be taken into account. In other words, the personal element entered into the problems whichever instrument was used. The human agency was necessary for determining the time the boxes had to be left in the furnace. The author had stated that these boxes took from $2\frac{3}{4}$ to 3 hours to reach the necessary hardening temperature, and he, Mr. King, presumed that this applied to single cutters only, and that corrections would have to be made for the mass of a number of articles packed together. He agreed with nearly all the author had said in the paper, and was happy to find that the same experience obtains in their works at Swindon and the Government offices. In conclusion, Mr. King briefly spoke of the method of tempering he employed. The metal was heated to 900 deg. Cent., cooled to 650 deg. Cent., and then quenched in cotton-seed oil. With this method he had been able to increase the life of his tools by four to five times that previously obtainable.

Mr. Francis Carnegie agreed with the four essential points put forward by the author for ensuring as long a life as possible for the cutter, and to these he added the design of the tooth. He gave as the best design, which, however, was not agreed to by some of the subsequent speakers, that the rake on the cutting face should be 5 deg., as shown in the sketch, and not radial, as was so often the case. The reason for the rake he gave that it rendered the tool a better cutter.



The speaker then compared the relative advantages of strong toothed cutters and those with a larger number of teeth. He gave the cost of the former as 35 per cent. less than that of the latter, and the life at from three to five times as great. Another important factor in the life of cutters was the lubricant used. Not so long ago he had been told by a motor car engineer that since he had used distilled water much better results had been obtained, and he, Mr. Carnegie, remarked that condensed steam would have the same effect. Personally, he used water and a special oil in the proportion of 50 to 1, and obtained excellent results.

Mr. W. Carter, of Sir W. G. Armstrong, Whitworth and Co., of Manchester, then added a few remarks to the discussion. He cited an example of the enormous saving due to the use of high-speed steel, but this was for lathe work. He contended that the use of this steel for milling cutters was at least five years old. Considerable stress was laid on the fact that in too many cases the first cost of the steel was the all-important factor, which it certainly ought not to be. He criticised the author's method of hardening, and objected to the use of a closed furnace. One of the essential features of hardening was that although fusion should be approached it should not be actually reached, and how could the author tell this when the cutters were put in a closed box which was heated to fusion heat? He had examined the cutters sent round for inspection, and had seen results practically as good obtained from open hardening. Cooling was not the important factor in the handling of high-speed steel, but heating was, and the greatest care should therefore be taken with it. Dealing with the question of hardening, he stated that if air was present in excessive quantities the cutter was alternately heated and cooled, and this caused scaling. In one part of the paper the author had referred to "cold damp air" being delivered to the cutter. He asked for the temperature of the air. He emphasised the importance of annealing high-speed steel before it was sent away from the maker's works. It had often been said that high-speed steel was not successful with hard materials. With this he did not agree, and gave an instance where his firm was machining nickel-chrome armour plate at a speed of 75ft. per minute. In another case, where gears were being cut for tramway work with high-speed steel tools the work was now done in one day, as compared with three before.

Mr. Hale, of Swindon, dwelt at some length on the question of the increase in size of the mandril hole after reheating, and to overcome this difficulty he suggested that the cutter holes should be made conical, so that the extra "play" could be easily taken up. He briefly outlined the annealing process adopted at Swindon. This consisted in using small coal dust mixed with sawdust in the proportion of two of the former to one of the latter. The material was placed in a box containing this mixture and heated to a temperature of 900 deg. Cent. It was allowed to remain for an hour, and the dampers were then put down and the box allowed to cool. The metal was then found to be quite soft, and no difficulty was experienced in cutting it. Heating, however, was by far the more essential point, and he thought that before long the question of heating would be of paramount importance, whereas tempering would become quite a secondary consideration. He fully confirmed Mr. King's statement that tempering with cotton-seed oil was a very good method.

Mr. Longridge made a few remarks concerning the

paper. It had been said that cutters of wide pitch had superseded the others, and according to the author they were now made with helical teeth, and he suggested that this was done in order that the cutter would always be in contact with the metal. The President also added to the discussion, confining his remarks chiefly to points already referred to by previous speakers. He could not agree with Mr. Carnegie when he gave a definite angle for the rake of a cutter's teeth, because the angle, he considered, depended upon the consistency of the material it was desired to machine. Dr. Ashton was then called upon to reply.

Replying to Mr. Hughes, the author remarked that powdered charcoal was used because it contained a large amount of silicious matter. The main object was not to carbonise the material but to give it a non-oxidising atmosphere during heating. Damp air was used for cooling because it was a more rapid cooler, and remained at a comparatively constant temperature throughout the year. Also in answer to Mr. Hughes, he said that the helical angle was generally one turn of the spiral to fifty diameters of the cutter. He agreed with Mr. King's remarks concerning the life of cutters, and added that some steel punches and dies which he knew of had made 2,000,000 blanks, as compared with 200,000 formerly, and the tool was still running well. With regard to Mr. Carter's denunciation of superficial fusing, the author concurred, but he thought that the best results were those where the metal just began to run, and this temperature could only be ascertained by the careful supervision of the furnace. He defended the Fery pyrometer at some length.

The meeting then adjourned till Friday, January 17th, when the nominations for the annual election of the Council will be made.

GREENWICH BOILER EXPLOSION.

THE Board of Trade inquiry on the explosion of a thermal storage tank at the Greenwich Station of the South Metropolitan Electric Light and Power Company, which commenced on Monday, 16th inst., continued until Thursday evening, when it was adjourned till January 15th. We have already dealt with the proceedings of the first three days, and it remains only to give now a brief account of the progress—the very slow progress—which the inquiry made on Thursday. In the morning the examination in chief of Mr. Spyer, of Babcock and Wilcox, Limited, was continued. He was asked if he had formed any opinion as to why the plate had failed, and he replied that, whilst his view did not amount to an opinion, he had, by a process of exhausting all other probable causes, arrived at the theory that the fractured plate was made of steel which had the peculiar property known in France as *fisselité*. Such a plate would be very liable to crack on surface injury, and through it a crack would be very readily propagated. That plates having this peculiar quality were very rare he admitted, but they undoubtedly did now and then occur. He thought it possible that cracks might be started in a plate of the kind he had in mind by such bruising as was indicated by the "chain of indentations" in the fractured plate, and in that case they would start from the inside. He did not entirely agree with Mr. Kolle about the indentations, but whilst he thought they were severe, he did not think that they should have materially injured the metal. He did not consider that they were a sign of bad workmanship, but he thought they showed that the workmanship was not of the best; the marks were perhaps a little too severe. Questioned as to the depth of the old crack from the inside, he said that the drumhead appeared to have been hanging by a film of steel $\frac{3}{32}$in. thick. This he judged from an examination made on the day after the accident. It was quite impossible to estimate the actual length of the crack from the external signs. Asked as to what he would have done had he seen the crack before the explosion, he thought it was possible he would have directed the boiler to be shut down, but it was impossible to say definitely; in such cases everything turned on a personal inspection. He did not think the fact that the crack appeared to be taking up was any indication of its seriousness or otherwise.

On cross-examination Mr. Spyer admitted that all ordinary tests showed the plate to be a good one. He could form no idea when the crack extending two-thirds of the circumference had started, but he did not think it could have existed when the boiler was hydraulically tested. The chain of indentations was produced by the snap head being a little too high up, and his firm had taken steps to prevent its occurrence in the future [Elucidation of this statement will be found in Mr McLaren's evidence, which is given below.] Questioned by Mr. Nicholls, who was acting for Babcock and Wilcox, the witness said that he had examined other drum ends and had found them indented in the same way and practically to the same extent, but they were all apparently sound. This confirmed his view that there was some difference between the burst plate and the others. He thought it was one of those cases of mysterious fractures in steel which were much discussed by engineers. He would not expect cracks caused by the indentation of normal plates to extend, and he did not consider a surface crack in itself dangerous. The fact that Mr. Bowden, the engineer to the electricity company, had sent a message about the leak indicated to him that Mr. Bowden did not consider the crack serious or he would have shut down at once; but, in answer to the Commissioner, he admitted that if he himself saw a crack of the kind in a new boiler he would regard it as dangerous. In reply to a question by Mr. Hallett, Mr. Spyer said that he considered such drums quite safe without stays.

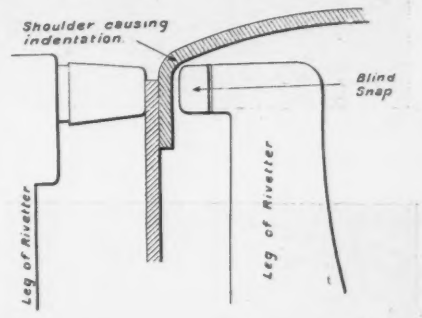
Mr. Bowden was then recalled and questioned at considerable length by the Commissioner and Mr. Hallett as to the boiler power at the Greenwich station, the possibility of transferring the load quickly to Sydenham, and the steps he would have taken to shut down the boiler had he deemed it necessary. In reply to the last question he said that he would damp the fires, blow off the water slowly at the blow-off cock, and possibly ease the safety valve very carefully. He thought it possible that with such a large quantity of water in the drum it would be dangerous to take the pressure off suddenly, as there might be a rapid and dangerous generation of steam. Altogether he thought—although he had no actual experience on which to form an opinion—that from half to three-quarters of an hour would be required to shut down a boiler fitted with a thermal tank. Mr. Spyer, questioned on this point, differed from Mr. Bowden, and thought the operation might be safely performed in five minutes. There was no more difficulty in dealing with a boiler having a thermal tank than one without.

Mr. McLaren, the works manager at the Babcock and Wilcox works, Renfrew, was then called, and said that after the accident he gave Mr. Carlton, the Board of Trade inspector, an opportunity of seeing how drumheads were constructed at the works.

Mr. Carlton reported on what he saw, and his report was read out. In it he describes how the plates are heated to a bright red heat in a large furnace, and then flanged in an hydraulic press at one operation. They are still bright red when they leave the press, and are stacked one above the other and shielded with iron sheets so that they may cool regularly and slowly. Those ends which have manholes, like that which fractured, are reheated all over for punching and again for flanging the hole. The ends are usually driven into the barrels, but occasionally they do not fit, and the hydraulic riveting machine is used to press the surfaces together, being fitted with a blind snap for that purpose. It was the corner of this snap catching the knuckle of the flange that caused the chain of indentations.

Mr. McLaren said that he wished to make two remarks on this portion of Mr. Carlton's report. First, he wished to say that the drum ends had *always* to be driven into the barrels; and, secondly, he did not agree with the description of the making of the indentations. The report stated that the depth of indentation varied with the pressure employed; that was not so. The depth depended upon the position of the drum relative to the snap, and since there was nothing supporting the plate behind the indentation the full load of 60 tons could not be exerted, since there was no equivalent resistance. The witness explained what he meant on a drawing which had been put in in evidence. The annexed sketch, for which accuracy is not claimed, will make the production of the "chain of indentations" clear.

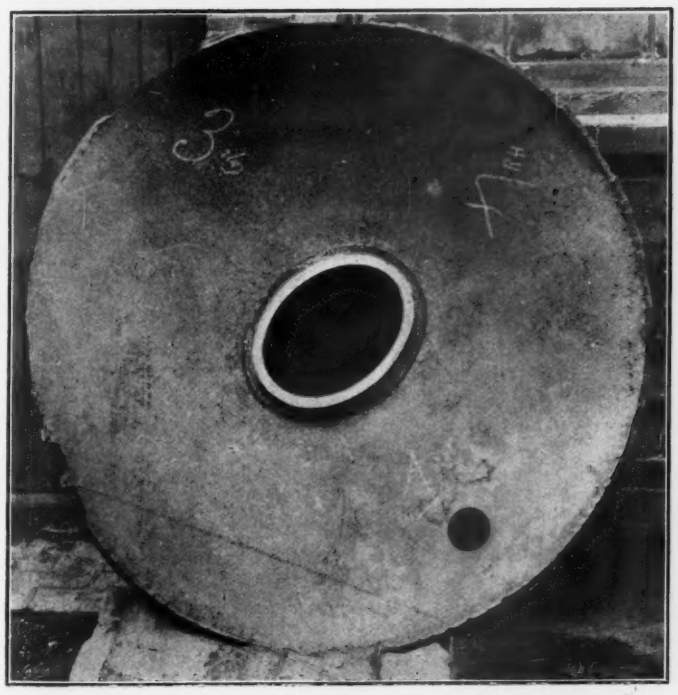
The sketch shows the two legs of the riveter and the



blind snap attached to the inner leg. It will be observed that the upper part of the snap meets the curve of the plate at the knuckle, the result being that a small pocket is pressed locally in the plate. The thickness of the plate is little or at all reduced, there being no resistance to prevent it bulging. We mention this particularly, because read literally, the sketch we gave last week showed considerable reduction of the thickness of the plate. It was only intended to show the position of the indentation, but the point should be made clear.

Mr. McLaren was still giving evidence when the Court rose, the case being adjourned, as already said, to Wednesday, January 15th.

Through the courtesy of Babcock and Wilcox, Limited, we are enabled to reproduce two remarkable photographs of the fracture. One shows the disc of metal driven out of the drumhead, and the other the drum itself viewed from the burst end and with the fractured flange of the end plate still in position. The chain of indentation can be seen fairly well in the former engraving, and the peculiar saw-tooth form the fracture has taken may be also studied, whilst close examination will show the depth to which the crack had originally extended, and the remaining "film" of sound metal which held the plate in until the fatal moment. The apparent opening at the end of the barrel is a false impression given by the engraving.



THE BROKEN END PLATE AND BARREL OF THE THERMAL STORAGE TANK

THE Admiralty intend to proceed at once with the erection of a torpedo factory at Greenock. The site chosen is a field adjoining Fort Matilda, and it has already been marked off by the authorities, who will acquire the land under compulsory powers.

NEW STATION AT SYDNEY.

THE New South Wales Railway system was opened in September, 1855, and at that time a corrugated iron shed, with a long wooden platform and two or three wooden rooms for the convenience of the public and the staff, erected at a cost of £2012, served the needs of the city of Sydney. Ten years later, however, the necessity for improved railway station accommodation was brought under the notice of the Government, and between the years 1871 and 1875 a sum of £53,000 was voted for new station buildings, workshops, goods sheds, &c. The first portion of the new building was opened in 1875, and was erected on the site where, on the 3rd July, 1850, the Hon. Mrs. Keith Stewart turned the first sod of the first Australian railway. Additions were made from time to time, but the traffic grew so rapidly that the accommodation very quickly became inadequate to meet the increasing traffic of the Colony.

After several years' consideration had been given to various schemes for the building of a new terminus at Sydney, Royal assent was, on 11th December, 1900, given to an Act of Parliament, authorising the extension of the railway from the southern to the northern side of Devonshire-street, Sydney, and the erection there of a commodious terminus station and administrative offices. The general design of the new station buildings is the result of deliberations of a special committee, consisting of Mr. E. C. Stanley, engineering chief of the Queensland railways; Mr. Norman, engineer for existing lines, Victorian railways; Mr. Firth, engineering chief for existing lines, New South Wales; and Mr. Vernon, the Colonial architect. This committee consulted with Mr. Henry Deane, engineering chief for railway construction in New South Wales, so far as the general principles and the details of this scheme which he had prepared, and the design was afterwards submitted to and approved by the Minister for Public Works and also the Railway Commissioners. The preliminary operations were carried out under the superintendence of Mr. Deane, but when, in connection with a reorganisation of the Public Works Department, Mr. Deane retired from the public service, the plans of the works and the erection of the main floors were entrusted to the Colonial architect, and are being carried out under the immediate supervision of Mr. McRae, the principal assistant architect. Preparatory to the erection of the station buildings a considerable amount of preliminary work in the shape of clearing the site of old property, excavations, &c., was necessary, whilst further difficulty was encountered from the fact that a portion of the ground required for the new station yard had previously been used as a cemetery, and the bodies had to be removed and re-interred in a specially laid out cemetery a few miles distant from Sydney.

The new station is built in the form of three sides of a quadrangle. On the west it faces Pitt-street; on the north, Belmore Park; and on the east, Elizabeth-street; the south being reserved for the ingress and egress of trains. Externally the façade is built up with double channelled and moulded quarry-faced stone courses, with wrought detail work to all openings and features, the great thickness of the walls giving an excellent display of light and shade. In one of the engravings—Fig. 3—we illustrate the northern front, but the full effect of this cannot be realised, as, although the stone entablature of the colonnade roof gives a great amount of character, yet, until the whole is completed to its full height, its correct proportions will not be apparent. When the station is finished the main façade will exceed 117ft. in height from the pavement in Rawson-place, and the clock tower 250ft. in height. The building, however, as now erected, although incomplete, provides all the accommodation necessary for the public and also for the officials who have to deal immediately with that portion of the business of the railway department; but it does not provide for the general staff in connection both with the administration of the railways and tramways, nor for the numerous sets of offices now accommodated about Redfern and rented premises in the city.

The new assembly platform is s 348ft. by 70ft., having an area of 24,360 superficial feet as compared with an area of 10,170 superficial feet at the old station. The average length of the platforms is about 700ft., by a width of 30ft.; the whole area for passenger movements being 172,387 superficial feet, as compared with 78,750 superficial feet at the old station. The actual length of the

Fig. 1—VIEW OF THE PLATFORMS

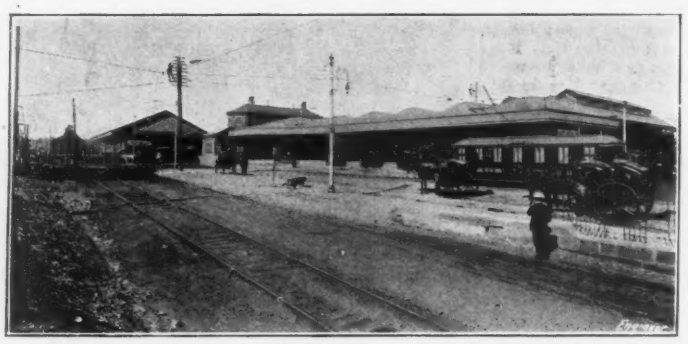


Fig. 2—THE OLD STATION BUILDINGS

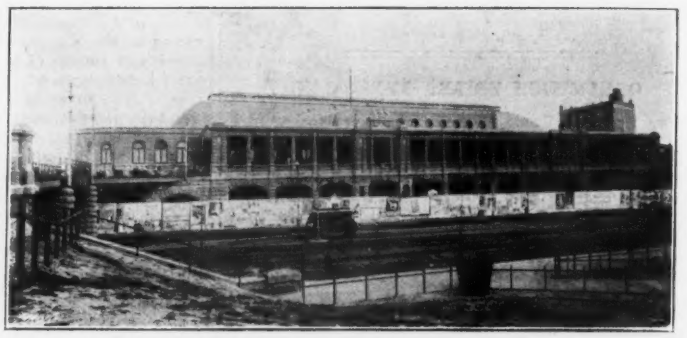


Fig. 3—THE NORTHERN FRONT OF THE NEW STATION

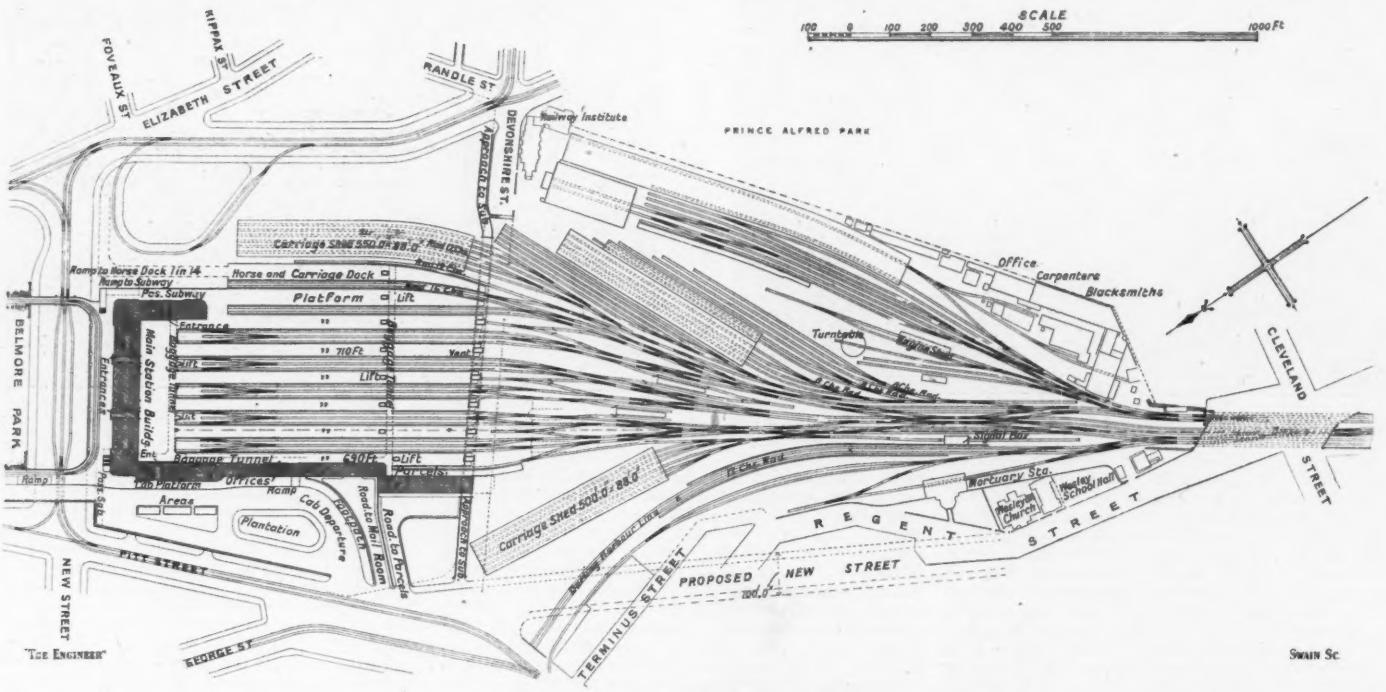


Fig. 4—PLAN OF PLATFORMS AND SIDINGS

lines within the platform docks for train service is 12,748 lineal feet, while at the old station there were only 5810 lineal feet. These figures indicate that for the accommodation of trains and passengers rather more than double space will be available at the new than at the old station, but the actual advantage, apart from these areas, is that a very largely increased business can be handled with greater convenience and freedom from the delay which attached to previous conditions, as the main lines entering the station yard are increased from four to six,

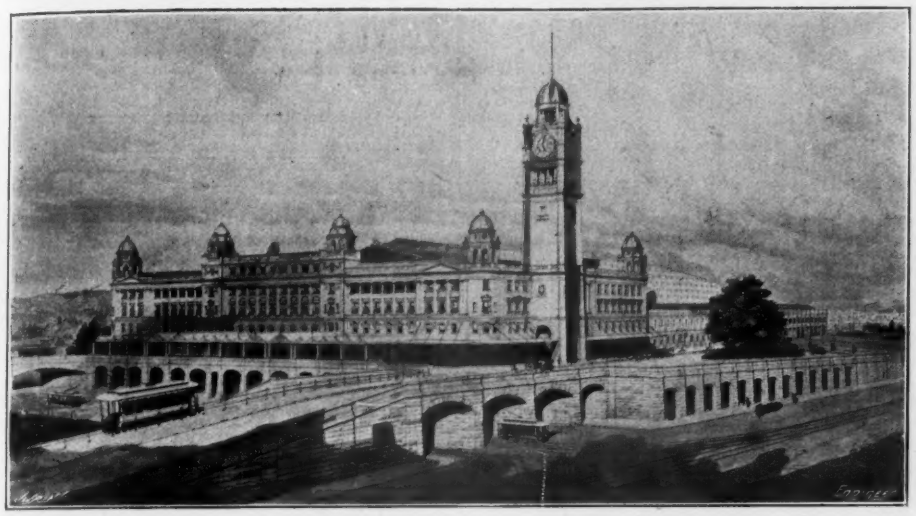


Fig. 5—PERSPECTIVE VIEW OF THE NEW STATION

and these fan out practically into double the number of independent lines of approach to the several platforms. As will be seen in the engraving, Fig. 4, connections are so arranged and interlocked that three trains can be entering and three leaving the station, or six trains be in rapid movement at any one time. Through connections, coupling all six main lines, are provided, so that trains may cross from one side of the yard to the opposite, and all through roads, scissors, crossings, and crossovers will be interlocked with the signals worked on the electro-pneumatic system. The entire interlocking work of the new station is done from two signal-boxes. The main box, placed a few yards north of the present old station box, and the existing box at the tunnel have been demolished, and the second box erected just in front of it and between the Illawarra and slow lines. The old mechanical principle entailed much manual labour, and thus limited the distance from which points or signals could be worked from a signal cabin. In the electro-pneumatic system the points, lock-bars, and signals are worked by compressed air supplied to motors at the points and signals from a generating station, the movements of the motors being controlled by electro-magnets, manipulated from the signal-box. There is no manual labour, the signalman having merely to complete the electric circuit to the points or signals by means of miniature levers.

In the old yard the station signal-box controlled 26 points, 23 bars, and 65 signals, which, with five spaces for additional levers, made it necessary to have an interlocking machine with 119 levers. In the tunnel signal-box 22 points, 23 bars, 71 signals, and one spare lever necessitated a machine with 104 levers—or, for the whole station yard, 223 levers for working 48 points, 33 lock-bars, 136 signals, including six spare levers. In the new station yard the station signal-box controls 71 points and lock-bars, and 116 signals, with 30 spaces for additional levers, which would be equal to a mechanical interlocking frame of 217 levers; but owing to the adaptability of the system for selecting signals—making one lever work more than one separate signal, the proper signal being given with different combinations of the point levers for various routes—the 187 points and signals require only 137 levers to work them, leaving spaces for 30 additional levers in an interlocking frame of 167 levers. Similarly, in the new tunnel signal-box, 19 points and 70 signals are controlled by 49 levers, which, with 10 spaces for additional requirements, make up the 59 lever frames. Taking the two signal-boxes together, it will be seen that 90 points and 186 signals require only 176 levers to actuate them, without taking into consideration the lockbars to the points, which, under the new system, are worked by the same motor which controls the points.

The "Annett Route Indicator" is another innovation introduced in the plant. The object of the system is to reduce as much as possible the number of semaphores, signal arms, and lights to an approaching driver, thus preventing the possibility of a signal for any particular route being mistaken. The indicator, which has been approved by the Board of Trade, and which has had a practical trial for some time with satisfactory results, provides for the reduction in the number of separate signal arms. One signal arm only is provided for each running line, and the particular route is "indicated" in a receptacle below the arm, showing to which road the train is required to proceed. By the introduction of this principle the number of semaphore signal arms for running lines will be reduced from thirty-six to eleven, and sixty-six shunting signal arms will be reduced to twenty route indicators. Most of the route indicators and running and shunting signals are fixed on steel lattice girder bridges, spanning the six sets of rails. One of these bridges, 82ft. in length, spans six lines of rails, about 100 yards on the city side of the Redfern Tunnel. This bridge carries five semaphore arms and thirteen route indicators, and to complete the scheme, another has been erected at a position near the outer ends of the old railway station platforms, or almost opposite the junction of Regent and Terminus-streets. This bridge is over 150ft. long, and spans the whole of the running lines and some sidings, and carries five semaphore arms and sixteen route indicators.

To increase the facilities in dealing with the suburban traffic, the train accommodation has been very largely increased. Two new carriage sheds, each capable of accommodating six trains, have been built, and sidings to accommodate an additional number of seven other trains are also being constructed. The new carriage shed and the siding accommodation are connected to suitable shunting necks, so that the movements of these trains when being taken into and out of traffic are independent of the main lines, and the obstructions which frequently occurred under the old conditions are to a very great extent eliminated, while the blocking of incoming and outgoing trains in the yard, which was formerly unavoidable, is obviated entirely. The total mileage of main lines and sidings, within what may be called the station yard limits, that is, between Redfern Tunnel and the station docks, is about fifteen miles, and we believe that there are not many stations in other countries which have greater accommodation in this respect.

The arrangements for the handling of heavy passenger luggage are very complete. The access to the luggage office is from the street front to the building, and when received, all heavy luggage, parcels, &c., are transferred to the basement of the building by means of electric lifts, and thence to the trains or brake vans by trollies moving on tramways provided in the subways for this purpose. By keeping the luggage and parcels clear of the platforms, it is more expeditiously dealt with, and with less inconvenience to the passengers. For the convenience of those who arrive at or leave the station by vehicles, a covered platform is provided on the western side of the building, and between the cab approach and the line of Pitt-street, the northern side of the station is beautified by a considerable area being laid out as a plantation. The trams to and from the city pass the north or main front of the building, and take up and discharge passengers under a covered way extending along the front of the building for a length of 300ft. It was at one time the intention to cover the whole of the platforms with one large roof, but this proposal was abandoned owing to the great cost of such a structure, and the lack of its necessity in the dry and temperate climate of Australia. The platform coverings are therefore in the form of awnings, which give all the necessary protection from the weather, and as the docks are open, the smoke from the locomotives is diffused and does not create the murky atmosphere sometimes found in stations where the complete roofing has been adopted. Over the assembly platform there is a fine semicircular roof of steel, covered with galvanised iron, and with ample glazing to give all necessary light to the platform below.

In the spacious booking hall, Fig. 6, the dimensions of which are 110ft. by 54ft., there are fixed, in the recesses on either side of the main passage ways, indicating boards denoting the windows in the booking-office at which passengers can obtain tickets for the various lines. Eleven windows are provided, and after obtaining their tickets passengers pass through the halls on either side of the booking-office to the assembly platform.

The main refreshment room on the assembly platform is 54ft. by 49ft. A ladies' dining room, 29ft. by 13ft., and a gentlemen's dining room, 57ft. by 43ft., are connected with the main room.

In the basement, starting from the Redfern end of the western wing is the lower inwards parcels office, combined with the mail room, covering together an area of 15,000 superficial feet. Liberal provision has also been allowed for the Civil Ambulance and Transport Brigade, which has not only accommodation on the ground floor for offices, casualty room, stable and coachhouses, but on the mezzanine floor living quarters for a number of officers. Accommodation has been provided for dealing with the outwards parcels traffic, the space occupied covering an area of 4800ft. in the building itself. It is approached from the street through two archways between the shops in Pitt-street, the approach leading into a large courtyard, with an unloading platform and offices. At the west corner of this floor is the basement of the luggage room above, measuring 72ft by 58ft. It is provided with special appliances for the rapid transit of luggage to the floor above, and thence to the subways. In the basement of the main building facing Belmore Park, on the right of the long corridors, are the extensive rooms and shops appropriated for the electrician's department, covering an area of no less than 9500ft., in which is placed the whole of the machinery for transmitting power and energy for use in the station generally. Beyond this are additional storage rooms of great extent, and also cellarage in connection with the refreshment rooms.

The main entrance for foot passengers from the city by way of George and Pitt streets is at the corner of Rawson-place and Pitt-street. The passengers here enter a double subway, the left-hand portion of which is ascended by an easy grade, and the right-hand portion by two flights of steps leading to the booking hall on the assembly platform. Passengers from Pitt-street can also enter the station at the corner of Pitt and Hay streets, an avenue being provided on an ascending grade to the booking hall. Foot passengers from the eastern parts of the city reach the station through a subway on the eastern side, the entrance being at the corner of Rawson-place and Elizabeth-street. Those from the western suburbs enter the main gates at the south-western end from George-street, near the old station.

Fig. 6—THE BOOKING HALL

ROYAL INSTITUTION OF GREAT BRITAIN.—As already announced, the Royal Institution Christmas course of illustrated lectures, adapted to a juvenile auditory, will be on "Astronomy, Old and New," and will be given by Sir David Gill, K.C.B., LL.D., D.Sc., F.R.S., M.R.I. The lectures next week and the week after will be held on Tuesday, December 31st. 1907; Thursday, January 2nd, 1908; Saturday, January 4th, 1908; Tuesday, January 7th, 1908; Thursday, January 9th, 1908. Lecture hour, three o'clock.

LIGHT PETROL LOCOMOTIVES

SHEFFIELD CAR COMPANY, CHICAGO, ENGINEERS

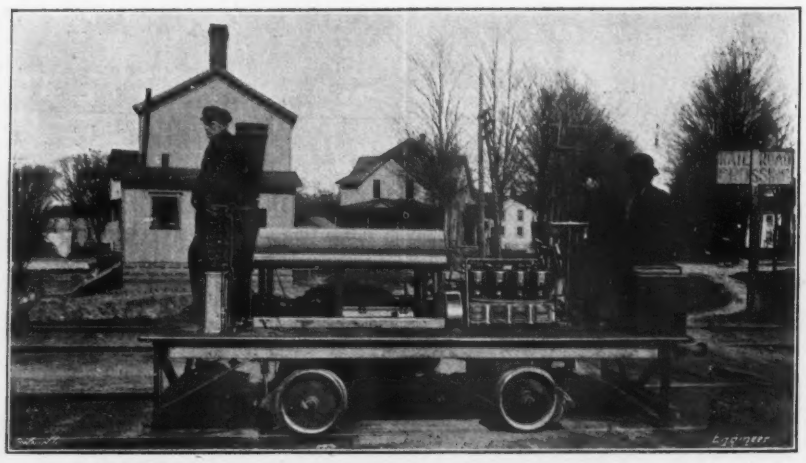


Fig. 1—INSPECTION CAR

Fig. 2—LOCOMOTIVE FOR PLANTATION WORK

LIGHT PETROL LOCOMOTIVES.

The use of platelayers' lorries and maintenance-of-way inspection cars operated by petrol engines is very general on American railways, and the same arrangement of apparatus has now been applied to light locomotives for use on construction work and at such places as brickyards, factories, plantations, mills, &c. One of these machines, built by the Sheffield Car Company, of Chicago, is shown in the accompanying illustration—Fig. 1—but without the cab to enclose the machinery and protect the driver. It consists of a platform wagon mounted on two axles, and carrying a Sheffield four-cycle petrol engine as made for automobiles. A four-cylinder engine is used on the larger locomotives and a two-cylinder engine on the smaller ones. This drives a planetary transmission gear for three speeds from 5 to 12 miles per hour. From the countershaft run two sprocket driving chains, one to each of the axles. Water and petrol tanks are fitted, and ballast can be added to increase the weight. The smallest locomotive, of narrow gauge, weighs less than two tons, and can haul about 10 tons on level line. A two-cylinder petrol locomotive for plantation work is shown in Fig. 2.

THE TRAINING OF ENGINEERING APPRENTICES.

Four years ago a Committee of the North-East Coast Institution of Engineers and Shipbuilders prepared a scheme for recording the educational progress of engineering apprentices. This system was recommended by the Committee for adoption by the engineering firms on the North-East Coast and elsewhere connected in one way or another with the Institution. Several works have since adopted the system of marking, with or without modifications designed to meet the special requirements and circumstances of local industry. Among the first to introduce the system were Swan, Hunter and Wigham Richardson, Limited, at their Neptune Works, Walker-on-Tyne. In a paper read last week before the Institution at Newcastle, Mr. W. G. Spence gave a record of four years' working, and indicated some of the results obtained by the adoption of the scheme.

The whole of the apprentices in the works, many of whom attend evening classes at the Armstrong College of the University of Durham, or classes conducted under the auspices of the Board of Education and the City and Guilds Institute, are awarded marks for timekeeping, industry and conduct in works and evening study. The marks in the latter division are apportioned on a graduated scale for examination passes. The result of each apprentice's work in a given year is shown on a diagram by means of curves, and a framed copy of this diagram is hung up in each department of the works and remains on exhibition until replaced by the following year's results. Mr. Spence in his paper gives examples of the curves for the year 1907, and a number of curves exhibiting the annual variation and progress of the average results obtained by the apprentices during the four years the system has been in operation. The names of the apprentices in the actual works diagrams are arranged in the order given by the aggregate of marks obtained. It is noteworthy that the general improvement shown by the apprentices during the four years is more marked in the lower divisions of the tables than in the figures referring to the lads of ability above the average. This fact seems to indicate that the incentive to work and study afforded by the idea of competition has had the desired effect among the apprentices of average and under average ability and industry. The curves showing the marks for timekeeping indicate a decided improvement. The marks for conduct and industry in works are awarded quarterly by the foremen under whom the apprentices are working. Mr. Spence observes that this method of testing the relative conduct of the lads is good in principle, but its practical application is affected by the introduction of what he terms the human factor. "The foremen," Mr. Spence says, "undoubtedly endeavour to allocate their marks conscientiously, but there is naturally a wish on the part of every one of them to see the names of the young men under his charge well up on the list, which is liable to bias the judicial faculty, and it is extremely difficult for anyone to place each youth in correct perspective."

The conclusion Mr. Spence draws from a study of the diagrams is that the number of apprentices who do efficient evening class work forms a very small percentage of the whole, and that, save in a few exceptional cases, the work is of quite a rudimentary character. Little more than 20 per cent. of the apprentices show any results at all from evening study. Incidentally, Mr. Spence considers the results indicate a justification for the argument that the attention of those responsible for the allocation of educational grants should be specially directed to seeing that such grants are so arranged that the small percentage of specially able and hardworking youths are afforded facilities for passing on to the higher technical schools and colleges, and that the chief business of evening classes should not be the production of a light crop over a large area, but rather the giving of assistance, enabling a few to train themselves above the average and to pass on to further advancement.

Only a very exceptional youth, strong both mentally and physically, can make any great headway by evening study, and, at the same time, work regularly and well in the works from 6 a.m. to 5 p.m. With the view of minimising this difficulty in favour of the really deserving, it has been arranged at the Neptune Works that the apprentice at the head of the list in each year shall during the ensuing winter commence work at 9 a.m. instead of at 6 a.m., full-time pay being credited. The system adopted at the Neptune Works has evidently been attended with some degree of success, and the particulars now made public in Mr. Spence's paper will be of interest to many engineers responsible for the management of large engineering works.

BELLEEK SLUICE GATES.

Although nearly a quarter of a century has elapsed since the time they were erected, the sluice gates of Belleek still possess the distinction of being the greatest in the world. The Lough Erne drainage and reclamation works, to which this set of enormous gates forms the key, have proved the most successful undertaking of the kind so far carried out in Ireland—a country which stands in need of more remedial schemes of a like nature—and their benefit to the district is incalculable. Lough Erne is formed by two vast lakes, connected near Enniskillen by a narrow channel. The one runs up at no great distance from the town of Cavan, the other comes down to the neighbourhood of the sea—the Atlantic in Donegal Bay—above Belleek. The upper lake, like the eastern end of the lower one, is covered with innumerable islands, forming practically a network of lagoons, and the shores in most places are low and swampy. The drainage of a huge watershed falls into it, so that the waters along its whole reach formerly rose annually in the autumn to a great height, viz., 10ft. above the summer level, submerging for months about 18,000 acres of low lying but productive land, representing a loss of £50,000 per annum. The great expenditure necessarily involved gave the death-blow to most of the remedial measures projected from time to time over a long period; but eventually a scheme, satisfactory alike from the engineering and the financial standpoint, was arrived at. It was decided to destroy the picturesque falls of Belleek, forming the outfall of the lake, and in the widened gap thus created to build sluice gates, which would dam back the outflow of the water, or increase the outlet with the rising flood, so as to maintain the summer level in the lake all the year. No less than 200,000 tons of intensely hard rock were blown away to form the gap in which the gates are inserted, and many more were similarly disposed of in making a good channel of approach. The gates themselves, which were set up in the year 1883, are constructed of a strength to resist the enormous static pressure of the lake, which gives 15ft. in depth here. Each of the four sluice gates is 29ft. in span, and weighs 13 tons, while they overlap each other, to give additional strength. The gates are equipped with the ingenious adaptation of movable rollers—the patent of Mr. F. G. M. Stoney, M. Inst. C.E., who personally superintended their erection—which eases the jam of the water pressure at the sides, while the river, acting on a turbine, gives the power that regulates them. One small hand wheel, which a child may turn, suffices to raise or lower them. When fully raised, the sluices are capable of discharging five million gallons per minute. Information that the water is rising in the upper lake is conveyed from Belturbet, at the upper end, by means of a self-registering telegraphic apparatus placed there, to the operator at Belleek. The cost of the works amounted to £190,000, of which £15,000 was subscribed from the consolidated fund, as much more was advanced and charged upon adjacent baronies, and the balance was furnished mainly by the promoters, viz., landowners profiting by the reclamations and improvements.

THE SLUICE GATES AT BELLEEK

The importance of the good achieved by the Lough Erne drainage system cannot be overrated, although the tourist has to deplore the disappearance of the beautiful cataract, pronounced by the late Sir Joseph Paxton to be "the most picturesque he had ever seen," and the angler the grave injury that the works have inflicted upon the Ballyshannon salmon and eel fisheries, which in 1866 changed hands for the sum of £45,000. But the same autumnal flood which used to charm the visitor to the Belleek rapids brought dismay and poverty to the farmer, who saw his fields, laden with the fruit of a season's care and industry, ruined by the rising waters. A subsidiary, but important, part of the scheme has yet to be carried out, namely, the opening up of navigation through the whole of Lough Erne, and its connection by means of canals, portions of which exist, with Dublin, Belfast, and Limerick.

In consequence of the successful application of his invention at Belleek, Mr. Stoney's services were engaged for the construction of the Manchester Ship Canal, for which he provided a number of similar sluice gates.

It is reported that the Indian Railway Conciliation Board has agreed unanimously on all the points in dispute after three days' sitting. It is hoped that the Boards will settle similarly any future disputes.

RAILWAY MATTERS.

THE Austrian State Railroads recently made contracts for 1,754 000 sleepers. Of these 28·9 per cent. are to be oak, 26·5 larch, 42·4 fir, and 1·8 beech.

THE Bill for the construction of the Mount Magnet Black Range Railway, to assist mining development, has been passed by the Western Australian Parliament.

THE traffic manager of the Liverpool tramways, who invented a new sanding apparatus which has been fitted to 300 cars, has now added an arrangement for dealing with a car running backwards.

H.M. CONSUL at Bucharest reports, on the authority of the *Curierul Financier*, that the Roumanian Government have decided to allot to the State Railways the sum of 50,000,000f.—£2,000,000—for the purchase of rolling stock, the construction of new sidings, and various other works.

A REPORT from Montreal states that the establishment of pensions on an unexpectedly liberal scale by the Grand Trunk Railway is hailed with delight on the part of the workmen of the company. The decision also means the immediate retirement of 200 aged workmen who will be able to pass the rest of their lives without work.

PRIZES for track supervisors to the value of £1080 were distributed by the Pennsylvania Railroad in October for the tracks maintained in the safest and most perfect condition. The largest prize, £240, was for the line best maintained during the year, and the next largest, £200, for the division showing the greatest improvement. The remainder of the sum was divided into four £160 prizes for divisions showing especially good maintenance and improvement.

THE mileage of steam railways in Greece is 865 miles, and their total capitalisation £8,440,000. They are not owned by the Government, but are built after its permission is obtained. The State also pays in part of the construction, and hence controls the passenger and goods rates and other details. The Government participate in the benefits, and have the option of taking over the lines within a specified period, while at the lapse of another period the railways become the property of the State. The motive power of the first railway built in Greece was put in operation in 1869, running from Athens to Piræus, six miles.

THE introduction of electric traction on railroads that have long tunnels appears, says the *Electrical World*, to have had an extraordinary effect on the development of short and long tunnel schemes in Switzerland. Some of the plans for intercanton and international routes are very ambitious, involving sums as large as £11,000,000 in indi-idual instances. Including local trolley enterprizes, there are already in Switzerland 111 projects for which concessions have been granted. It is obvious that the execution of even a small number of these projects would not only require a very large sum of money, but would call for large quantities of hydraulic and electrical apparatus.

PASSENGERS by a morning train from Belfast to Bangor, county Down, last Sunday had a narrow escape. Immediately after the down train to Belfast had passed Craigavad a heavy fall of earth and rocks occurred at a deep cutting, and into this the Belfast train dashed at a considerable speed. The approach to the cutting is a sharp curve, and the driver had barely time to shut off steam before the engine had penetrated some distance into the *débris*. The fireman was thrown against the fire-box and seriously hurt internally, while several passengers complained of shock. The line was blocked for several hours, necessitating heavy Christmas mails being conveyed by horse traction.

THE author of a paper on the "Choice of Frequency for Single-phase Railway Motors," read before the American Institution of Electrical Engineers, points out that while 15 cycles gives better commutation and higher efficiency, there is no net reduction in weight as compared with 25 cycles. The coefficient of adhesion is slightly reduced with the lower frequency, and there are difficulties in the construction of the generators. The general use of 25 cycles for power supply is a strong reason for adopting that frequency for railway working, and it is open to question whether the type of motor on behalf of which a lower frequency is advocated is so much superior to other types as to justify the departure from existing standards.

THE Great Northern Railway Company of Ireland intends at an early date to transfer its large locomotive works from Dundalk to Belfast. The directors of the company have had the scheme under consideration for some time. It is understood that one of the principal reasons which actuated them in their decision was the necessity for acquiring greater scope and facilities to meet the increasing demands of their service. The site which has been acquired in Belfast is in the vicinity of the Bog Meadows, and the contemplated works will cover a much larger area than the present engine shops in Dundalk. The transfer will involve a heavy loss to Dundalk, as about 600 men are employed in the works, while a sum of £30,000 is paid in wages annually.

A NEW improvement is shortly to be tried in Leeds tramcars. This consists of the provision of a partition or screen dividing the car into two compartments, not necessarily of equal dimensions. This will save inconvenience in more directions than one, and apart from its making it easier for the conductor to seat his passengers, the latter will be largely freed from the annoyance of having to "move up" in a body to accommodate a late arrival. The designs of the new cars are to come before the Traffic Committee at their next meeting. Meanwhile, visits have been paid to various towns with the view to studying the latest types and providing the Leeds public with a car which contains a maximum of convenience and comfort. The new cars are to be made in Leeds at the tramcar workshops.

THE scheme for providing through bookings to cover practically all the London underground railways is making progress. It was recently announced that a decision had been arrived at between the District, the Metropolitan and the various tube systems to establish a comprehensive scheme of advertising, this being facilitated by the adoption of the uniform title of "Underground" at all the stations. In order to facilitate the exchange of passengers between the Central London and Piccadilly tubes it is proposed to connect the British Museum and Holborn stations by means of a low-level subway. An alternative to such a long passage would be the removal of the former station a short distance westward, where underground communication between the two stations could be more easily effected.

ACCORDING to the *Engineering Record* the Surprise signal tests made during October on the Pennsylvania Railroad were the most satisfactory ever made. There were 2245 of these tests, and of them 98·8 per cent. were absolutely successful, and the remaining 1·2 per cent. were marked deficient merely because the signals were passed only a few feet. Taken as a whole, the October record was 1·2 per cent. better than that of September, the best previous month. Fifteen entire divisions received a perfect rating, while only ten divisions were so rated during September. Five divisions were above 97 per cent., and only one fell below 90 per cent. The skill attained by the trainmen in observing signals is shown by the fact that there was but one failure in the 952 tests on the very busy lines of the Schuylkill division.

NOTES AND MEMORANDA.

ACCORDING to *Power*, 80 per cent. of the sulphur production of the world comes from Sicily.

IT is announced that the Poulsen Company has been successful in transmitting a wireless telephone message from its Weisse see station at Berlin to its Lyngby station at Copenhagen, a distance of nearly 250 miles.

ARTIFICIAL stone is made by mixing the cement, sand, water, &c., at a temperature of about 39 deg. Fah. The mixture is kept under compression until it hasset, the temperature being at the same time decreased to 32 deg. Fah., or lower, whereby the expansion of the water in falling through this range of temperature is caused to increase the compression.

THE total quantity of coal shipped from the Tyne during the eleven months of 1907 was 16,022,351 tons, as compared with 15,364,282 tons during the eleven months of 1906, an increase of 658,089 tons, or 4·28 per cent. The coke shipments were, in the same period, 314,696 tons, against 287,854 tons in 1906, an increase of 26,842 tons, or 9·32 per cent.

THE cement production in the United States, according to the annual report issued by the United States Geological Survey, continues to show greatly increased figures. In 1887 the total Portland cement output in that country was 250,000 barrels of natural cement, while for the year 1906 the production rose to 46,000,000 barrels of Portland with only 4,000,000 of natural.

A CONTEMPORARY remarks that objection has been made to the drop-by-drop system of oiling on the ground that it tends to niggardliness in the supply of oil, and actually induces waste, since the oil is liable to be burned and practically useless after going once through the bearing. For surfaces working under severe conditions the forced oil system may be used to good advantage, but has the disadvantage of dependence upon a pump.

AMALGAMS for the frictional parts of electric machines are combinations of quicksilver, tin, and zinc. The quicksilver is heated to 302 to 392 Fah., transferred to a wooden box, the melted tin and zinc added to it, the box closed by a lid and mixed by vigorous shaking. The proportions of the mixture—according to Singer—are (*a*) 6 parts of quicksilver, 2 parts tin, 1 part zinc; (*b*) 7 parts quicksilver, 4 parts zinc, 2 parts tin; various other proportions of these ingredients are sometimes used.

WE hear that cinders from locomotives are being used for making producer gas at two places in Germany by the railway administration. One plant, at Koenigsberg, has three generators and three double-acting gas engines, each of 180 horse-power capacity. The engines are direct connected to electric generators. The other plant has two gas generators and two single-acting gas engines, each of 90 horse-power. Both plants are said to be giving satisfaction, the consumption of cinders being reported from 1·3 lb. to 2·4 lb. per horse-power, varying with the load.

TO platinise iron, says the *Scientific American*, first heat and give it a coat of 22 parts of borate of lead and 4·5 parts of blue vitriol mixed with turpentine to a paste, washing it off after a while. Platinising formula:—10 parts of platinum, changed into platinic chloride, mixed with 5 parts of ether and exposed to the air until the ether is evaporated. The residue is mixed with 20 parts of borate of lead, 11 parts of red lead and some oil of lavender to a paste, which is mixed with 50 parts of amyl alcohol. Dip the object in the mixture, dry and heat it.

A CAR ferry service across Lake Ontario has been placed in operation between the Genesee River, above Rochester, New York, and Cobourg, Ont., a distance of 60 miles, by the Grand Trunk and the Buffalo, Rochester and Pittsburg railways. The boat, which is expected to make two round trips in twenty-four hours, is said to be the largest on Lake Ontario, being 316ft. long, 57ft. 4in. beam, and drawing 17ft. It has a capacity of twenty-six cars, and is expected to develop a considerable coal carrying trade. Though intended primarily for freight, passenger accommodations have been provided on the upper deck.

ELECTRIC heating is being tried in France for drying paper in place of steam. Where the machine permits, it is considered preferable to place the resistance, in which the heat is developed electrically, against the inside metal walls of the cylinders. A special advantage claimed for this system of heating is said to be the ease with which the temperature of the cylinder can be regulated while in operation. While such drying calls for a considerable amount of current, it is believed in the French plants where the experiments are being conducted that the cost is not excessive where current is furnished by hydro-electric plants belonging to the mills.

THE de Faria electric "valve" differs from the Nodon "valve" solely in the shape of the electrodes, which are claimed to secure automatic circulation of the electrolyte. Wattmeter tests of the efficiency of a 4·5 ampères set at the Laboratoire Central showed a mean efficiency of 53 per cent, the test lasting 7¼ hours; the hottest part of the electrolyte rose to 43·8 deg. Cent. At this temperature the efficiency was in one case even higher than at the lower temperatures. It is stated that the average efficiencies of larger sizes reach the following values:—10 ampères, 65-70 per cent.; 30 amperes, 65-75 per cent.; 50 ampères, 70-80 per cent.

THE Dandot coal mine of India, says the *Engineering Mining Journal*, has a system of timbering that compares favourably with any other system used in any country. The seam is from 2ft. to 3ft. thick, and is worked by the longwall method. Wooden "chocks," 2ft. square, are built at a distance of 4ft. 6in. apart, measuring from centre to centre. Props are set in advance the same distance apart, and these form centres for the "chocks" as the work progresses. Planks 1½in. thick and 6in. wide are set above the "chocks" and props and kept close to the face. Thus the miners are always protected by timber when working. The timber is set by specially-appointed men.

SINCE August 1st two electrically-driven vans have been used in Hamburg for collecting and carrying letters from the outlying to the central office. According to the *Rundschau für Elektrotechnik und Maschinenbau*, the vehicles carry a battery whose capacity is 90 ampère-hours and two 2·5 horse-power motors. The standard speed is about 10 miles per hour. The receptacle for the letter bags extends from the driver's seat to the rear axle. It is provided with movable sides which slide in slots, and which, when removed, permit the rapid unloading or loading of the sacks. A small box, placed immediately under the driver's seat, is used for the conveyance of registered packages.

IT is stated in the *Pioneer Mail* that the new road bridge across the Sittang was opened by the Lieutenant-Governor of Burma on November 5th. This is the largest and most costly bridge in the province, and has involved an outlay of over £25,000. It consists of four central spans of 104ft. each, with land spans of 95ft. at either end. The girders were obtained in England and put together with pins, bolts, and nuts, no riveting of any kind having been done on the spot. The construction and maintenance of the bridge and road will greatly facilitate access from Rangoon to the hill station of Lower Burma, and it will now be possible to reach Thandaung within twelve hours of leaving Rangoon; travellers starting by the evening train will be there for breakfast next day. This is partly due to the enterprise shown by the company, which has instituted a motor car service, while the action of the Government has provided the bridge and road.

MISCELLANEA.

A NOTTINGHAM miner has patented a safety pit cage which is claimed to be a great advance on all its predecessors.

IT is reported that a new works for the production of iron ore briquettes is to be built at Bredsjö, in the province of Westmanland in Sweden.

THERE is a proposal to construct an extensive dry dock at the New King's Dock, which will be the biggest in the Bristol Channel. The estimated cost is £250,000.

THE *Boletin Oficial* of Argentina, of November 8th, contains a copy of a decree authorising the Inspeccion General de Puentes y Caminos to construct an iron bridge over the Arroyodel Medio, on the road from Pergamino to Rosario, at a cost of 85,000 pesos currency—about £7437.

DURING the present year considerable improvements, additions, and alterations have been made to the collieries' plant and furnaces at the Blaenavon Coal Company at a cost of £62,000. In one pit electric haulage is now installed, and arrangements have been made for plant of this kind for the whole of the collieries.

WE hear that the experiments that are to be carried out by the battleship Vengeance and the armoured cruiser Ariadne at Portsmouth with an invention for controlling gunfire have been postponed until January. In addition to the Ariadne, the destroyers Kale, Derwent, Doon, and Ribble are to take part in the experiments.

THE Coventry Town Council recently decided to make application to the Local Government Board for sanction to loans amounting to £35,000 for purposes of their electrical undertaking. It is proposed to expend £10,000 of this amount on extensions to distributing plant, and the balance on the laying of new mains in the extended area of supply.

THE Bell Telephone Company is at present negotiating with the Government of Manitoba with a view to selling the telephone system in this province. The Provincial Government recently decided to establish its own system of telephone, and it is probable that the company's lines will be purchased outright in preference to setting up a new system.

THE Clyde shipbuilding statistics for the year show another record in ships launched and the horse-power of engines constructed. Five hundred and nine ships were launched, of an aggregate of 620,000 tons, against 372 ships, of 599,000 tons last year. Eleven years ago the highest total was 400,000, and six years ago the half-million was reached.

ACCORDING to a contemporary, in some respects the Bellerophon, at Portsmouth, is not so far advanced as her sister ship the Temeraire, at Devonport, for whereas the latter has had her tripod mast shipped that of the Bellerophon has not yet made its appearance. A great deal of progress has, however, been made with the Portsmouth ship in other directions.

AN extensive wireless telegraph system has been erected by the United Fruit Company on its fruit steamers, and at numerous points on the Gulf of Mexico and the Caribbean Sea, for communication between the offices, steamers in transit, and its plantations in Central America and the West Indies. A station was recently added at San Antonio, at the extreme western end of Cuba.

A REPORT from Washington states that the Commission appointed by the Secretary of the Interior issued a pamphlet recently on coal-mine accidents, showing that 22,840 persons lost their lives in the United States of America during the past seventeen years. Half of these deaths were caused within the last six years. During the year 1905 6361 persons were involved in accidents, 2061 of them perishing.

FORMAL notice was recently given of the intention to promote in the ensuing session of Parliament a Bill relating to the Malvern Hills. Among other things, this will propose to enlarge the powers of the conservators, to prohibit quarrying on any part of the Malvern Hills in a manner that may prove to be a temporary or permanent disfigurement of the same, and to empower the conservators to make and enforce by-laws for regulating the operation of quarrying on any part of the hills.

WE hear that the work of electrifying the machinery and plant in the factory and workshops of the North Yard, Devonport, being practically complete, attention is being directed to the South Yard workshops and smithery, in which during the past week or two large deliveries of power motors, principally of 10 and 20 brake horse-power, have been made. Some idea of the magnitude of the electrification of the Western Dockyard will be gathered from the fact that over four hundred motors will be employed.

THE Labour Department of the Board of Trade report that employment in November showed, on the whole, some decline, both as compared with the previous month and as compared with a year ago. In coal mining employment remained good, but in the shipbuilding industry it was bad. In the 272 trade unions, with a net membership of 639,678, making returns, 32,010, or 5 per cent, were reported as unemployed at the end of November, 1907, as compared with 4·7 per cent. at the end of October, 1907, and 4·5 per cent. at the end of November, 1906.

THE Registrar of Imports and Exports at Singapore reports that at a meeting of the Tanjong Pagar Dock Board the tender for the construction of a main wharf and lagoon dock by a well-known London firm of harbour engineers was accepted, the contract price being £993,700. The work will comprise 4575ft. of wharfage with a depth of 35ft. at low-water mark, 20-ton blocks of concrete being used up to low-water mark, and above that massed concrete. The lagoon dock will have 3800ft. of wharfage with a depth of 30ft. at low water in ordinary spring tides, the walls being composed of massed concrete.

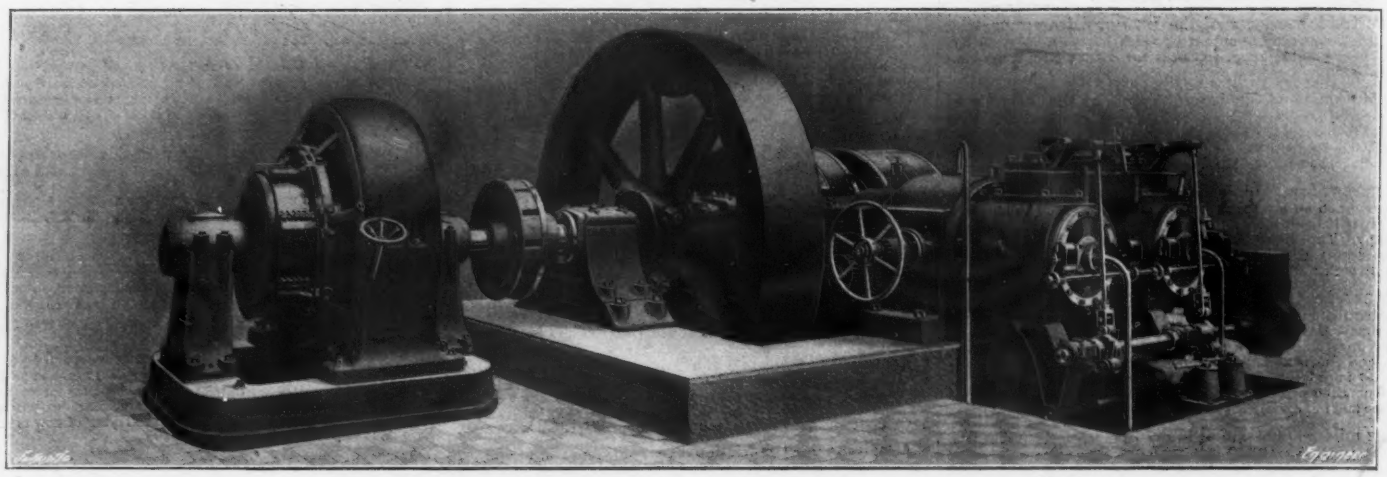
FOR years, says the *Iron and Coal Trades Review*, the steel industry has confidently expected to see a fulfilment of the prediction made long ago that "the open-hearth process will go to the funeral of the Bessemer." Recent developments indicate rather clearly that the function will be a wedding instead of a funeral, a vastly more happy occurrence. The duplex process is rapidly gaining in favour, and the details are being worked out in different ways by different metallurgists. It is more a matter of appliances and manipulation than processes, as the metallurgical work is laid out very clearly.

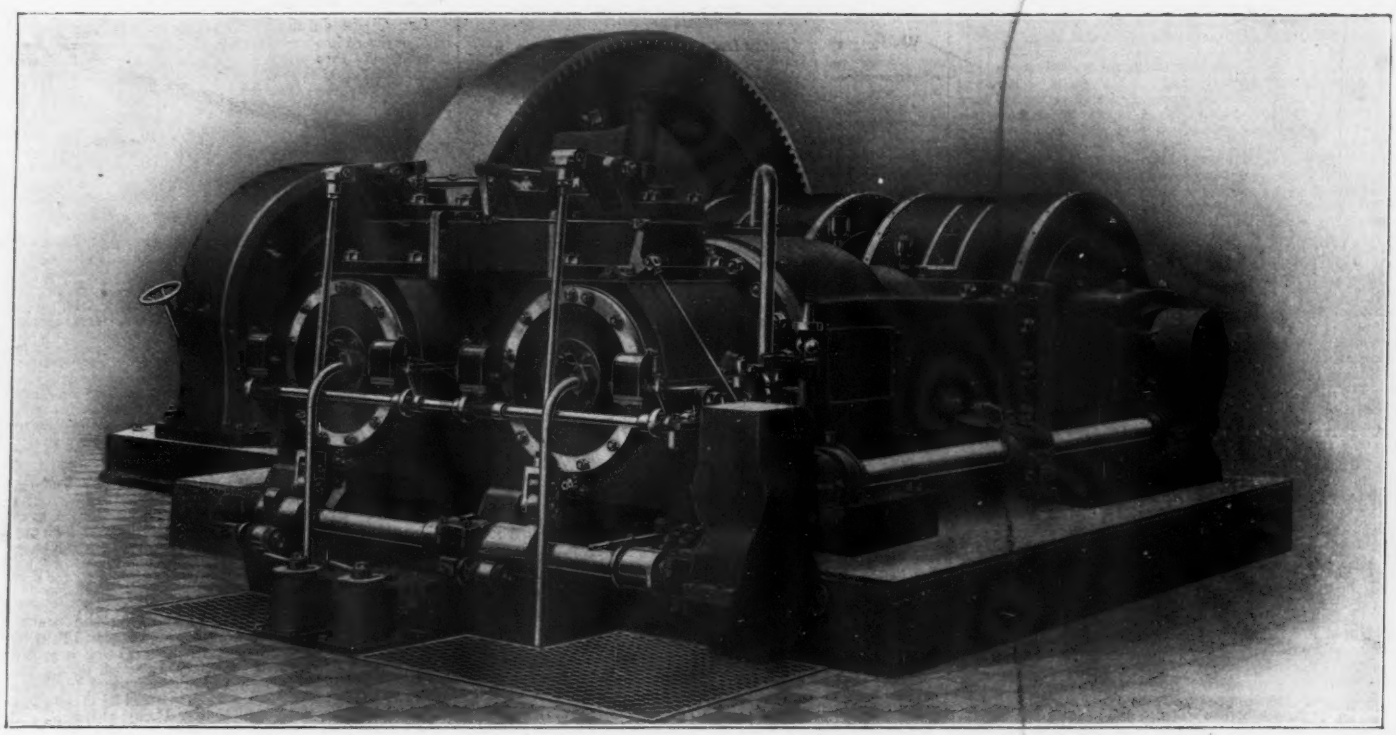
IN the course of the meeting of a congress recently held in the McCoy Hall of the Johns Hopkins University it was stated, according to the *Boston Transcript*, that if one-half of the swamp lands of the United States were reclaimed they would afford homes and support to 12 million persons, by giving to each family a farm of 40 acres. The increase of the value of, say, 50 million acres by drainage operations would be 1000 millions sterling, and it is estimated that a like sum would be spent on that acreage for improvements. The average cost of drainage is set down at £1 per acre, and a Bill was introduced into Congress at the last session dealing with the drainage and reclamation of swamps and flooded lands. This Bill provides for the application to drainage schemes of the same system as that now applied to irrigation, and schedules a loan of £400,000 to the drainage fund, this sum to be repayable to the Government in ten annual instalments.

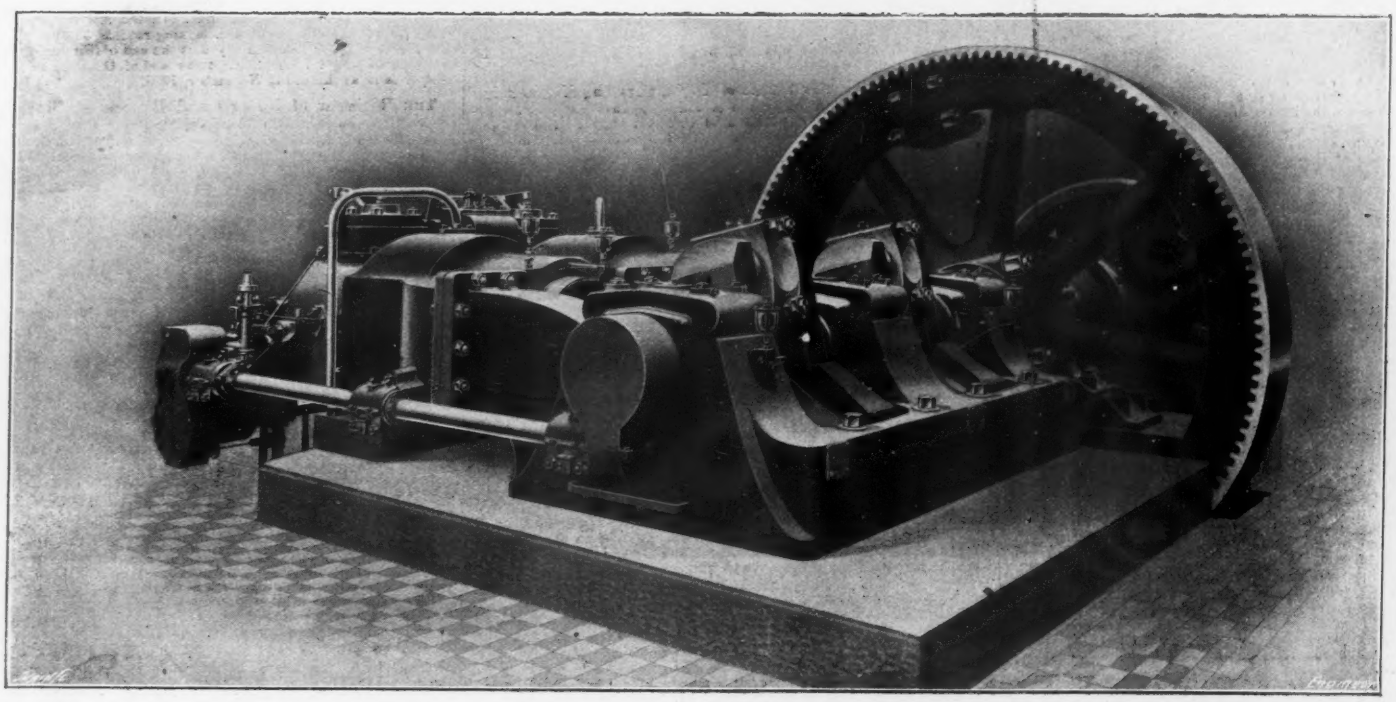
300 HORSE-POWER SUCTION GAS ENGINE

THE NATIONAL GAS ENGINE COMPANY, LIMITED, ASHTON-UNDER-LYNE, ENGINEERS

(For description see page 659)







FOREIGN AGENTS FOR SALE OF THE ENGINEER.

AUSTRIA.—F. A. BROCKHAUS, *Seilergasse 4, Vienna.*
CHINA.—KELLY AND WALSH, LIMITED, *Shanghai and Hong Kong.*
EGYPT.—F. DIEMER, FINCK & BEYLAENDER, *Shepheard's-buildings, Cairo.*
FRANCE.—BOYVEAU & CHEVILLET, *Rue de la Banque, Paris.*
CHAPELOT & CIE., *Rue Dauphine, 30, Paris*
GERMANY.—ASHER AND CO., 5, *Unter den Linden, Berlin.*
F. A. BROCKHAUS, *Leipzig*; A. TWEITMEYER, *Leipzic.*
INDIA.—A. J. COMBRIDGE AND CO., *Railway Bookstalls, Bombay.*
ITALY.—LOESCHER AND CO., 307, *Corso, Rome*; BOCCA FRERES, *Turin*; ULRICO HOEPLI, *Milan.*
JAPAN.—KELLY AND WALSH, LIMITED, *Yokohama.*
Z. P. MARUYA AND CO., *Tokyo and Yokohama.*
RUSSIA.—C. RICKER, 14, *Nevsky Prospect, St. Petersburg.*
UNITED STATES OF AMERICA.—INTERNATIONAL NEWS CO., 83 and 85, *Duane-street, New York*; SUBSCRIPTION NEWS CO., *Chicago.*
S. AFRICA.—WM. DAWSON & SONS, LIMITED, 7, *Sea-st.* (*Box* 489), *Capetown.*
CENTRAL NEWS AGENCY, LIMITED, *Johannesburg, Capetown, Durban, &c., and at all their Bookstalls.*
J. C. JUTA AND CO., *Capetown, Port Elizabeth, Johannesburg, East London, Grahamstown.*
AUSTRALIA.—GORDON AND GOTCH, *Melbourne, Sydney, and Queen-street, Brisbane, &c.*
MELVILLE AND MULLEN, *Melbourne.*
TURNER AND HENDERSON, *Hunt-street, Sydney.*
NEW ZEALAND.—GORDON AND GOTCH, *Cuba-street Extension, Wellington, and Bedford-road, Christchurch.*
UPTON AND CO., *Auckland*; CRAIG, J. W., *Napier.*
CANADA.—MONTREAL NEWS CO., 386 *and* 388, *St. James-street, Montreal*
TORONTO NEWS CO., 42, *Yonge-street, Toronto.*
CEYLON.—WIJAYARTNA AND CO., *Colombo.*
JAMAICA.—SOLLES AND COCKING, *Kingston.*
STRAITS SETTLEMENTS.—KELLY AND WALSH, LIMITED, *Singapore.*

Subscriptions received at all the Post-offices on the Continent.

SUBSCRIPTIONS.

THE ENGINEER can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office on the following terms (paid in advance):—

Half-yearly (including double number) .. .. £0 14s. 6d.
Yearly (including two double numbers) .. .. £1 9s. 0d.

CLOTH READING CASES, to hold six issues, 2s. 6d. each, post free 2s. 10d.

If credit occur, an extra charge of two shillings and sixpence per annum will be made.

Foreign Subscriptions will, until further notice, be received at the rates given below. Foreign Subscribers paying in advance at these rates will receive THE ENGINEER weekly and post free. Subscriptions sent by Post-office Order must be made payable to THE ENGINEER, and accompanied by letter of advice to the Publisher.

THIN PAPER COPIES.		THICK PAPER COPIES.	
Half-yearly	£0 18s. 0d.	Half-yearly	£1 0s. 0d.
Yearly	£1 16s. 0d.	Yearly	£2 0s. 0d.

(The difference to cover extra postage.

ADVERTISEMENTS.

☞ The charge for advertisements of four lines and under is three shillings, for every two lines afterwards one shilling and sixpence; odd lines are charged one shilling. The line averages seven words. When an advertisement measures an inch or more, the charge is 10s. per inch. All single advertisements from the country must be accompanied by a Post-office Order in payment. Alternate advertisements will be inserted with all practical regularity, but regularity cannot be guaranteed in any such case. All except weekly advertisements are taken subject to this condition.

Advertisements cannot be inserted unless delivered before Five o'clock on Thursday evening, and in consequence of the necessity for going to press early with a portion of the edition ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

Telegraphic Address, "ENGINEER NEWSPAPER, LONDON." Telephone—No. 13352 Central.

PUBLISHER'S NOTICE.

*** *If any subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the Paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

CONTENTS.

THE ENGINEER, 27th December, 1907.

	PAGE
MECHANICAL POINTS IN CONNECTION WITH STEAM TURBINES	641
THE ALWENT WATER SCHEME FOR BIRKENHEAD	642
THE HUMBER FISHING COAL CONTRACTS	643
THE PUY DE DOME ADHESION RAILWAY. (Illustrated.)	643
THE INSTITUTION OF MECHANICAL ENGINEERS	646
THE GREENWICH BOILER EXPLOSION (Illustrated.)	647
NEW STATION AT SYDNEY. (Illustrated.)	648
LIGHT PATROL LOCOMOTIVES. (Illustrated.)	650
THE TRAINING OF ENGINEERING APPRENTICES	650
BELLEEK SLUICE GATES. (Illustrated.)	650
RAILWAY MATTERS	651
NOTES AND MEMORANDA	651
MISCELLANEA	651
LEADING ARTICLES—The Influence of the Diameter of Driving Wheels	653
Average Cylinder Pressure—The Exchange of Knowledge	654
LITERATURE	655
PORT OF PARA	655
THE TELTOW CANAL. (Illustrated.)	656
LETTERS TO THE EDITOR—The Use of Superheated Steam—The Principles of Mechanics—The Vibration of Ships	658
NAVAL ENGINEER APPOINTMENTS	658
300 HORSE-POWER SUCTION GAS PLANT. (Illustrated.)	659
THE RAILWAY AGREEMENT	659
OBITUARY	659
NOTES ON THE MANUFACTURE AND UPKEEP OF MILLING CUTTERS. (Illustrated.)	660
THE INSTITUTION OF CIVIL ENGINEERS	661
CATALOGUES	661
AMERICAN ENGINEERING NEWS	662
LAUNCHES AND TRIAL TRIPS	662
AUSTRALIAN NOTES	662
AMERICAN NOTES	662
ALMANACS, DIARIES, &c.	662
THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS	663
NOTES FROM LANCASHIRE	663
THE SHEFFIELD DISTRICT	663
NORTH OF ENGLAND	663
NOTES FROM SCOTLAND	664
WALES AND ADJOINING COUNTIES	664
NOTES FROM GERMANY	664
PERSONAL AND BUSINESS ANNOUNCEMENTS	664
BRITISH PATENT SPECIFICATIONS. (Illustrated.)	665
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.)	666

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

W. E. F. (Newcastle).—There is no book on the raising of sunken ships.

C. V.—Your best course will be to apply to the Engine and Boiler Insurance Company, 12, King-street, Manchester.

C. R. K.—Through a clerical error you have been wrongly informed about our articles on "Commercial Organisation." Mr. Spencer's articles were published in book form by Messrs. Spon in February last.

INQUIRIES.

ANNUAL MAKE OF RAILWAY TIRES AND AXLES.

SIR,—Could any of your readers inform me what is the annual make in Great Britain of railway tires and axles for home use, and also for export? B.

December 23rd.

MEETINGS NEXT WEEK.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, December 31st, at 8 p.m. Social Gathering, by special invitation to the Junior Section.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—Thursday, January 2nd, at 8 p.m., at the Caxton Hall, Westminster, S.W. Discussion, "Standard Notation for Engineering Formulæ," opened by Mr. W. N. Twelvetrees, M.I.M.E., A.M.I.E.E.

THE ENGINEER.

DECEMBER 27, 1907.

The Influence of the Diameter of Driving Wheels.

IT was understood at a very early period in the history of the locomotive that large wheels and high speed went together. In the present day the truth of the proposition is fully recognised, and the reason why it is true is much better understood. Yet it is not certain that precise information on the subject is as fully diffused as it ought to be among railway men. In the United States a rough rule has long been in use—the speed of the engine in miles per hour is equal to the diameter of the driving wheel in inches. This is supposed to represent maximum speed; that is to say, an engine with 5ft. wheels cannot be run to advantage at anything over 60 miles an hour, or a 7ft. wheel over 72 miles an hour, and so on.

The ultimate efficiency of a locomotive depends on the pull which can be exerted on the hook at the back of the tender at different speeds. The speeds are, however, settled by the conditions of traffic. The loads are determined by the traffic manager, which is not quite the same thing. The locomotive superintendent has then three points fixed for him. He has to convey a given weight for a given distance at a given speed. What type of locomotive will do this best he has to find out. This process of finding out has gone on for so many years that it has become a fine art. It may be said in a general way that it is responsible for the multiplicity of locomotive types in use on railways all over the world. The ruling factors are the capacity of the boiler as a steam generator, and the power of the cylinders to use up all the steam the boiler can make. Now there is a limit to the first; that is to say, a locomotive boiler cannot evaporate more than a certain weight of water per square foot of heating surface per hour. There is a limit not only to the weight of coal that can be burned in a fire-box, but to the power of a fireman to get the coal into the box. If there is a limit to the rate at which water can be converted into steam—which is not certain—it may be said without fear of contradiction that it has not been reached in railway practice. Very carefully made experiments give 12 lb. of steam per square foot of heating surface per hour as the most that can be reckoned upon in regular daily work. Thus a boiler with 1500 square feet of surface ought to make 18,000 lb. of steam per hour.

We have next to consider how the steam is to be used. If the cylinders cannot take it then it will be wasted at the safety valves, or the rate at which coal is put into the fire-box must be reduced. At this point the conditions become very complicated. Let us suppose that the cylinders are too small. Then, other things being equal, let us reduce the diameter of the driving wheels. Instead of 600 cylinders full per minute use 700. But to argue that way is to overlook the fact that the consumption of steam by a locomotive does not necessarily increase at the same rate as the number of revolutions. On the contrary, there is a speed which represents the maximum draught on the boiler for steam. This is the result of the wire-drawing which always goes on save at the most moderate velocities. Beyond this speed the consumption of steam rapidly diminishes, while the draw-bar pull falls off. Let S = speed, T = draw-bar pull, then S × T = a constant, and the most efficient locomotive, *cæteris paribus*, is that which gives the highest constant; or, in other words, the greatest pull with a given horse-power at the speed laid down by the conditions of traffic. Let us now, retaining the same cylinders, try what can be done by increasing the diameter of the driving wheels. The tractive coefficient will be reduced, but the velocity at which the maximum draught of steam will be reached will be higher, because wire-drawing will not operate to the same extent, and a "fatter" diagram will be obtained.

If our readers have followed us thus far, they will see that for an engine of any proportions there must be a number of revolutions which is better than any other number, because it is that at which the cylinders can use up all the steam the boiler can make—that is to say, the maximum possible horse-power will be the greatest. So much being fixed, we have next to determine what the diameter of the driving wheels shall be; but that in turn is fixed by the speed at which the train must run. If the resistance and load are too great for the tractive power, then the proper number of revolutions cannot be got, and the whole boiler power cannot be utilised. To use a marine engine-room phrase when a propeller is too big or has too sharp a pitch, the "engines will be locked up." One way out of the difficulty lies in increasing the size of the cylinders; to this there are well-understood practical objections. Another consists in raising the boiler pressure. It is worth while to say here that no more engines with 8ft. drivers are being built. The normal express locomotive has wheels somewhere between 6ft. and 7ft. in diameter, and it is safe to assume that with wheels of this size, in practice wire-drawing need not become so great that the cylinders will not use all the steam a boiler can make.

The very elaborate experiments carried out over a series of years at Purdue University, and amplified at the St. Louis Exhibition, have brought into a very clear light the effect of varying conditions. Thus, one engine whose boiler could develop 1500 indicated horse-power, with driving wheels 5ft. 6in. diameter, had a constant draw-bar pull up to 24 miles an hour of 23,750 lb. From this point S × T gives a hyperbolic curve up to 80 miles an hour, at which speed the draw-bar pull has fallen to 7000 lb. Up to 24 miles an hour the cylinders could not use all the steam the boiler could make. From that point they could, and T × S thenceforth had to equal 1500 horse-power. Here, entirely apart from wire-drawing, the tractive effort fell off, but it fell off at a constantly diminishing rate. Thus, at 40 miles an hour it had fallen to under 14,000 lb., or little more than one half what it was at 25 miles an hour, but at 60 miles an hour it was 9500 lb. Professor Goss says:—"It is worthy of special note that the reduction in draw-bar stress with increased speed is not due to any reduction in the power of the engine, but is in response to a physical condition which must always prevail, namely, that when the available power is constant the force in action must diminish as the velocity increases." The additional diminution due to wire-drawing will be shown in a moment.

A noteworthy deduction from Professor Goss's investigations is that about 200 revolutions per minute is the best speed for engines intended to attain speeds of 50 to 60 miles an hour. We have endeavoured to show the conditions which lead up to this conclusion. One factor, however, remains to be noticed, namely, the relation which the point of cut-off bears to the economy of the engine. To follow this out in detail would exceed the limits at our disposal. It must suffice to give a few actual figures. In a given locomotive, a cut-off at 25 per cent. gave at 188 revolutions per minute a mean effective pressure of 29·6 lb., but at 296 revolutions the pressure fell to 18·3 lb. Again, the same engine, which had driving wheels 5ft. 3in. in diameter, cutting off at 35 per cent., had a mean pressure of 42·4 lb. at 188 revolutions per minute, and a draw-bar pull of 4639 lb., but at 55 miles an hour, or 296 revolutions per minute, the mean pressure fell to 27·4 lb., and the draw-bar pull to 2997 lb. If, now, instead of increasing the number of revolutions, the diameter of the wheels had been increased to 8ft. 3in., the number of revolutions would remain the same—188—the mean pressure would still be 42·4 lb., and the draw-bar pull would be 2943 lb. So far there is neither loss nor gain. But at 296 revolutions this

engine used 32 lb. of steam per horse-power per hour, while at 188 revolutions it required but 26·3 lb., a difference of 21 per cent. in favour of the lower piston speed. It must not be forgotten, however, that the power of starting a train would be less with the large than the small wheels in the inverse ratio of their diameters.

The general conclusion to be drawn from all these investigations is that for express or fast passenger engines the speed giving the best results all round —that is to say, as to power, draw-bar pull, and consumption of fuel—is about 200 revolutions per minute. Nor is it remarkable that this rule should have very wide application, because the volume swept out by pistons bears a fairly constant relation to the heating surface of a boiler. Wire-drawing or the ratio of expansion is practically the same in all locomotives. If only roads were level or nearly so over long distances, then the bigger the driving wheel the better, so long as the number of revolutions did not fall below about 200. But lines are not level, and the locomotive must of necessity be a compromise. We have heard wonder expressed that the 8ft. drivers used by Gooch on the Great Western and by Stirling on the Great Northern were able to pull the heavy trains which formed their regular loads. We have the clue to their success in the knowledge that their average cylinder pressures were higher than they could possibly have been with smaller wheels.

Average Cylinder Pressures.

On March 19th Mr. R. Royds, M.Sc., brought before the Institution of Engineers and Shipbuilders in Scotland a paper on "The Most Economical Mean Effective Pressure for Steam Engines," which was taken as read. This paper has already been dealt with in our issue for May 10th last. We do not propose to say much about it here. The author holds that an examination which he has made of records of engine trials proves that variation of mean pressure through wide limits has little or no effect on the economical efficiency of the steam engine, and that for obvious reasons the higher the mean pressure can be kept the better. Mr Royds, in a word, advocated the addition of higher mean pressures than are now favoured. The discussion took place on the same evening, but the official report, with the correspondence, has only been made public in the "Transactions" within the last few days. It is not necessary to follow the discussion in detail. Taken as a whole, it teaches a lesson which is by no means devoid of interest, and is well worth careful consideration.

The speakers were all men of eminence and ability, competent to speak with the authority which results from knowledge of the questions with which they dealt. They spoke at considerable length, and each could adduce facts to prove the soundness of his arguments. The general impression conveyed is once more, unfortunately, that nothing like a rational theory of the steam engine has yet been framed. The steam engine is all things to all men. It is practically impossible to make any statement about it that cannot be met by a counter statement. No one is sure of his ground. It is as true now as it has always been that no one can design a new steam engine and say with certainty, based on knowledge, precisely what its economic efficiency will be. The aggravating thing is that it is impossible to get the steam engine to verify thermodynamic laws. Of course, the laws are not wrong, but they will not apply; the difficulty is to know why; and most of the research work which has been done has for its object the explanation of indisputable facts. Thus, for example, it seems to be certain that the higher the pressure, and the greater the ratio of expansion, other things being equal, the more economical will an engine be. But Mr. Royds shows that this is not the case. Professor Mellanby agreed, for example, with Mr. Royds, and pronounced text-books wrong:—"He was afraid that many people had attached themselves to the side of low mean pressures because it was so much insisted upon in text-books. There the familiar hyperbolic diagram and the formula expressing the work to be obtained per pound of steam were given in such a convincing way that the majority accepted them under the impression that they were learning some great scientific truth. The curious thing was that it could be shown from first principles that mean pressures ought to be fairly high." He seems to base this conclusion on two factors, namely, first, the personal friction of the engine, as we may call it, to distinguish it from rope and lay shaft losses; and, secondly, that the difference between the indicated weight of steam and that of the steam actually used is the same, roughly, for all ratios of expansion. Mr. Andrews would not accept Mr. Royds' views, and quoted the result of experiments made at Sibley College in the United States, which showed that the most economical mean pressure was about 18 lb. per square inch, or about half that suggested by Mr. Royds, and he said, not unnaturally, that if the Sibley College engines could give results so different from the Durham College engine, and the engine tested by Dr. Mellanby, "it seemed to him that there was some important element or factor not common to all three." He went on to cite triple-expansion engines in the Navy with cylinder ratios 1 : 2, 2 : 5 which, according to Sir John Durston, were much more economical with 24 lb. mean pressure than they were with 35 lb. Furthermore, if reference was made to Bryan Donkin's list of the most economical engines, in The Engineer of October, 1899, it would be found, with one exception, that they all worked at from 18 lb. to 25 lb. mean pressure.

The argument in favour of low average pressure was carried further by Mr. J. A. Rudd, who held that the most economical engine in Scotland was working at about 21 lb., the steam consumption being under 9 lb. per indicated horse-power per hour. The spoken discussion ended with him, and was pursued in the shape of correspondence. As a rule, those who write balance their words, and in so far, at all events, there is a distinct advantage gained. Mr. Michael Longridge, on the whole, agreed with Mr. Royds conclusions, but he introduced qualifications. Mr. Royds had taken 6 lb. as representing the personal friction of the engine, but Mr. Longridge gave a very interesting table setting out the results of trials of sixteen mill engines—some quite new, others old; one, indeed, was a McNaughted beam engine which had been at work for twenty years; it required a mean pressure of only 1·81 lb. to run it. A pair of horizontal triple-expansion engines, quite new, just started, needed only 4·45 lb. A pressure of about 2·5 lb. may be taken as sufficient to overcome the friction of any good engine, and for this reason he would recommend a pressure lower than that suggested by Mr. Royds. On theoretical grounds, Mr. Mathey held that it was a great economic mistake to carry expansion too far; and he supported his argument by saying that "many continental constructors made two-cylinder compound engines, which rivalled if not surpassed in economy British three-cylinder compounds." To explain this, he added that the clearance was very small, and the cylinder ratios not more than 3·5 to 1. Bollinckx used a proportion of 2·3 to 1, and his ratio of expansion was only 4·6. His clearance was under 2 per cent. Farcot, of Paris, guaranteed a consumption of only 13 lb. of steam in a single-cylinder engine, with a boiler pressure of but 85 lb. If we followed Farcot's example, instead of three cylinders, 30in., 50in., and 80in. in diameter, we should use three single 35in. cylinders. Captain Sankey gave a qualified support to Mr. Royds, but he directed attention to the fact that experiments had shown that for the triple-expansion engine the range of almost equal economy was from 26 lb. to 36 lb.

Mr. Royds replied at considerable length; but, of course, he could not alter the fact that an able paper based on carefully conducted experiments did not convince his audience. So far as Mr. Royds and those who took part in the discussion are concerned, the world, apparently, is not in any way better informed as to the conditions of maximum steam engine economy than it was before. The clue to this inutility is, we think, furnished by Captain Sankey's statement just quoted, which amounts to saying that quite considerable changes in the working conditions have very little effect on steam consumption. It is this truth that renders the study of the steam engine so difficult. Abundant examples are available. Steam jacketing supplies one. It seems to make little or no difference, not only whether an engine is or is not jacketed, but how it is jacketed. Yet there are conditions, the precise *modus operandi* of which is very obscure, which may or may not render jacketing economical. It seems to be certain that clearance cannot be too small, and yet it can be shown on paper that its dimensions are of little or no consequence if compression is utilised to fill the clearance spaces. Many of the speakers were urgent that experiments should be carried out with large engines. But it has been argued that a college engine can teach all that can be learned. Furthermore, experiments are being made continually with large engines. Mr. Longridge has amassed an enormous quantity of useful data in this way. The truth appears to be that research and inquiry are proceeding, so far as the steam engine is concerned, in a species of mill horse round. Nothing really new is advanced in papers; nothing new comes out in discussions. The whole course of the inquiry is wrong in the sense that it is jejune. What is needed now is a new line of research which will ascertain what are the real phenomena of the production and destruction of steam—what are its true relations to metallic surfaces; what is the method of heat transfer, and so on. The amount of ignorance on all that concerns steam as steam is at once remarkable and deplorable. Disputes go on which are the results of differences of opinion, not of differences in knowledge, for the opinions have no true basis of knowledge on which to rest. The Institution of Mechanical Engineers appointed a Research Committee on steam jackets so many years ago that the precise date is almost forgotten, and they have arrived at no conclusions yet. Who will start afresh and open up quite a new line of inquiry for himself? We venture to think that discoveries are to be made which will repay him for much toil.

The Exchange of Knowledge.

One of the most interesting features of the discussion at the Institution of Mechanical Engineers on Friday evening was the very general expression of thanks for the valuable practical information which the author had, through the kindness of the authorities at Enfield, been permitted to make public; he had given away secrets that are usually jealously preserved; he had imparted to others knowledge which, by pains and experience he had himself acquired, and he was to be publicly thanked for his kindness. Is there not something anomalous in this gratitude? The paper was read before a great institution which exists for the interchange of knowledge, and it was written by a member of that institution, one, that is, who should have given freely of his knowledge to his fellow-members. Why, then, should he be made the recipient of an exceptional offer of thanks? The reason is only too plain. The freedom with which he offered his knowledge was exceptional; everyone knew that it is not the usual practice to tell openly all that you know; all were aware that it is more common to keep back valuable information than to give it away; and all felt that, although Dr. Ashton is engaged in a Government factory, and that the rules of competition do not apply, yet his kindness in imparting knowledge should be especially recognised. We join very heartily in thanking Dr. Ashton for his practical paper, at the same time that we regret that the uncommonness of the occurrence should attract special attention to it.

Our position gives us exceptional opportunities for observation, and we are disposed to think that, if anything, the tendency to withhold information about processes and designs is on the increase. A few years ago there was greater liberality in the exchange of information than there is now. We were suffering somewhat from foreign competition, and British engineers, proud of their own work, were glad to show it openly and fully to the world. The effect was good. The design of British machinery was equal to any that other countries could show, and the confidence with which drawings of the smallest details were published very favourably impressed the would-be purchaser. What was inside foreign machines he did not know, save in so far as the parts were illustrated by the beautiful but unsatisfying illustrations in catalogues. British machines were shown in detail from works drawings, and he could judge for himself as to their excellence. Now-a-days this excellent practice has fallen into desuetude. Manufacturers have got chary about publishing drawings, because they think they do well to keep from their competitors some secrets of their design. That policy we believe to be mistaken, but it is encouraged by American engineers, who are extremely diffident about the reproduction of drawings; and we must confess that were competition with that country the sole thing to be considered, the policy adopted by British engineers would be reasonable enough. But the issues are far greater. It is to the good of the whole trade and profession that the common stock of knowledge should be increased, and that everyone should help his fellow and get help in return by telling all he knows. It was with that object that scientific bodies, such as the Institution of Mechanical Engineers, were founded, and it is the privilege of the technical Press to carry on a similar good work. But neither one nor the other can do it without the assistance of those engaged in the practice of engineering. The material must come from the manufacturer, and it is a curious reflection that he should be chary about giving information of the highest educational value at the same time that he complains that the training of the coming men lacks the spirit of practice. For that the manufacturers are themselves largely responsible. Speaking on this subject before the American Institute of Mining Engineers, Dr. James Douglas, in urging the advisability of a freer exchange of knowledge, made the following observation:—"Were we free to appeal to purely altruistic

motives, it would be superfluous to argue in favour of complete knowledge and experience-sharing, but profit-sharing is after all the impelling motive of industrial advance to-day, as it has been in all ages, and to reconcile the admitted evils of secrecy with the admitted advantages of publicity, the patent laws have been framed. They have always given the patentee the right to use either in his person or through his agent his invention or discovery for a limited number of years, provided he describes it so fully that it can be practised by one skilled in the art. The publicity and knowledge conveyed by the specification stimulates the inventive faculties of others, and patented and unpatented improvements, along the line of the original invention, demonstrate both the value of publicity and the cupidity of men, even of the technico-scientific class." We might, possibly, add to this, as a remarkable corollary, that although the Government does its best to encourage the exchange of knowledge through the Patent-office, it is, generally speaking, excessively reticent itself, and it is well known that of late years it has carried secrecy to an absurd pitch.

In conclusion, we return for a moment to our starting place. There are in Government workshops opportunities for the execution of experiments which it is impossible for any but a few private firms to carry out. The results of those experiments are frequently of a kind that would be of great service to private manufactories, and we see no reason why they should not be given regularly to the public. We are not forgetting that Mr. Donaldson and his assistants have, both by contributing papers and by taking part in discussions, added a great deal to the common stock of knowledge, but we do say that even more might be done. The Royal Arsenals might become immense industrial laboratories whence knowledge of machines, methods, and processes would be circulated freely for the benefit of the whole community. Mr. Ashton has shown us the kind of knowledge which is acquired at Enfield, and his publication of it has been welcomed by men who propose to turn it to good use. But he has dealt with a tiny portion of a great factory, and there can be no doubt that volumes of useful information on scores of different processes conducted in Government factories might be written. We have had two or three samples of such ware, and they have been so good that we ask for more. But besides the invaluable assistance that the learning distributed by Woolwich and Enfield might be, consider the reflex value. Think of the effect that it would have upon Government factories if they had regularly to submit their methods of manufacture to public scrutiny, and think of the investigations they would find themselves compelled to undertake! They would become splendid educational establishments to themselves and to the world.

LITERATURE.

The Chemistry of Gas Manufacture. A Practical Manual for the use of Gas Engineers, Gas Managers, and Students. By HAROLD M. ROYLE, F.C.S. London: Crosby Lockwood and Son. 1907.

THE contents of Mr. Royle's book belie its title, "The Chemistry of Gas Manufacture," for, as the author points out in his prefatory remarks, it leaves the operations of gas manufacture alone. It is in reality a manual adapted for the testers who on gas works are engaged in the routine of analytical and photometric observations of which the results serve to guide the manager of the works in controlling the manufacturing operations. The ordinary tests employed are described, but the bearing of the results obtained therefrom on the manufacture of gas is indicated only in a few instances, and then very imperfectly.

The book opens with a short chapter on the Preparation of Standard Solutions, of which the one described last is termed "Di-tri-ortho-phosphate." This "solution" is entirely new to us, and it is only by a careful consideration of the method given for its preparation that we fathom that the author is probably referring to a copper compound which is sometimes used as an absorbent of sulphuretted hydrogen, though never in the form of a standard solution. The second chapter deals with coal, and we incidentally gather from it that France is not on the Continent, that cannel coke yields a very high quality gas, and that sulphuretted hydrogen is not a sulphur compound. These errors may be due merely to the author's inability to write what he intends to convey to his reader, but such a plea is not admissible in regard to his description of a method for estimating the amounts of carbonic acid and sulphuretted hydrogen in gas. He directs that the gas should be passed first through a series of four V tubes filled with soda lime, then through three Woulfe's bottles containing acidified solution of cadmium chloride, and finally through an experimental meter. The veriest tyro in analytical chemistry will detect here such a collection of sources of error as it would be difficult with intention to equal. Mr. Royle says that the increase in weight of the soda-lime tubes gives directly the amount of carbonic acid absorbed. But with his arrangement of the test the soda-lime tubes would have absorbed the moisture and sulphuretted hydrogen as well as the carbonic acid from the gas, and a small but uncertain amount of moisture would have been given up by the last tube to the gas. The increase in weight of the tubes would have no definite signification, and certainly would not represent the amount of carbonic acid in the volume of gas passed through them. Then Mr. Royle directs that the contents of the Woulf's bottles should be so treated that the sulphuretted hydrogen absorbed by them would be determined, and the result of that determination is said to give the amount of sulphuretted hydrogen in the volume of gas taken. As a fact, the anterior soda-lime tubes would absolutely prevent any sulphuretted hydrogen reaching the Woulf's bottles, and the determination would be a blank one. Thus Mr. Royle's method would greatly overestimate the carbonic acid in gas, and would find the crudest gas perfectly free from sulphuretted hydrogen.

We need make no further comment. The succeeding chapters deal indifferently with furnace testing and regulation, carbonisation, analysis of crude gas, of lime and of ferric oxide, ammonia, naphthalene, analysis of fire-clay, photometry and carburetted water gas. The text of the book covers 238 pages; then follows an appendix of nearly 50 pages, which is merely a reprint, with reduced diagrams, of the "Notification of the Gas Referees"—a Government publication which may be bought for a few pence. Two short appendices of no special merit and an index complete the work.

A Manual of Fire Assaying. By C. H. FULTON. 8vo., pp. 178, with 44 Illustrations. New York and London: Hill Publishing Company. 1907.

THE subject of this volume is essentially the assay of gold and silver as contained in ores and bullion, as although there is a final chapter on the assay of tin, lead, mercury, bismuth, and antimony, less than ten pages have been allotted to this complex group of subjects, a space manifestly insufficient for their useful discussion. The main subject has, however, been fully treated, and two of the chapters, those on the assay of complex ores containing sulphur and arsenic, and on special methods of assay, the latter referring more particularly to ores containing tellurium and zinc, are useful and interesting as giving the practice followed in the South Dakota School of Mines, where the author occupies the position of President and Professor of Metallurgy. In the introductory chapter on the equipment of the assay office, melting and muffle furnaces are noticed using coal, gas and mineral oil as fuel, the latter being special American patterns, which are probably not well known in this country, and may be usefully brought to the notice of assayers here. Sampling also receives full attention in Chapter III., the description of the methods of the assay office being supplemented by accounts of the practice followed in the large local smelting works. According to the preface, "the subject of fire-assaying is treated from the scientific and rational point of view rather than from that of the 'rule-of-thumb,' which strangely enough governs most modern works on the subject, and the chapters on reduction and oxidation, crucible assay and slags, and cupellation, outline scientifically the principles of assaying."

This has been done by the introduction of chemical and physical details at different places in the text, and disquisitions on the melting points of mixed silicates and lead and silver alloys, the latter for the purpose of elucidating the fundamental operation of fluxing, fusion, and cupellation. In connection with cupellation it is stated that the oxide of lead as it forms is absorbed by the cupel as a solid, because the temperature of the muffle is only 700 deg., while the melting point of litharge is 906 deg. This does not agree with the experience of the "rule-of-thumb" man, neither does the author himself believe it, as the statement is immediately followed by another to the effect that the temperature of the lead in the cupel is probably higher than that indicated by a pyrometer couple near it, as the brighter colour of the lead seems to show; and in another place, after several pages of discussion, the freezing point of lead and silver alloys are suggested as giving the proper temperature of cupellation. The subject is wound up by statements in a foot-note that the actual temperature has not been determined, that it is higher than that of the muffle, and that a determination will very much modify the present theory. In the same way, rather more than six pages, given to discussions on the fusing points of silicates and the proportioning of fluxes to the composition of the waste minerals in the ore, which, of course, involves a knowledge of their composition, are followed by the very proper remark that "In assay practice it is neither possible nor desirable to make analyses of ore before assaying," the assayer being supposed to have a sufficient working knowledge of minerals to recognise them at sight. The same thing, however, may be said of the elementary chemical details, many of which are unnecessary, and some decidedly misleading. The definition of assaying as "including all those operations of analytical chemistry which have for their object the constituents of ores and metallurgic products," seems rather to apply to mineral analysis than to assaying, which, as its name implies, is the art of trying minerals for particular constituents, usually gold and silver, by methods which are essentially different from those of mineral analysis, and as in all other arts, the useful parts of the text-book are those describing the experience of the successful practitioner rather than those dealing with abstract scientific points, a remark that applies equally to the present work as to the "rule-of-thumb" books with which it is somewhat unnecessarily contrasted in the preface.

SHORT NOTICES.

Earthwork Diagrams. By R. A. Erskine Murray, A.M.I.C.E., and Y. D. Kirton, A.M. Can. Soc. C.E. London: Crosby, Lockwood and Son, 7, Stationers' Hall-court, Ludgate-hill, E.C. Price 5s., or mounted on card 7s. 6d.—These diagrams give graphically the cubic contents for different heights of banks and cuttings, 66ft. or 100ft. chains. There are three diagrams printed on the same sheet. Full directions for using are also printed on the sheet, which are clear and concise. The sheet which has been sent to us is unmounted, and is suitable for pinning to a drawing-board or other flat surface. For office use we have no doubt that the diagrams, permanently mounted, would prove useful.

Grace's Earthwork Tables. London: E. and F. N. Spon, 57, Haymarket. Price 12s. 6d. net.—There are a large number of tables in this book for use in finding the cubic contents of formations of various widths and slopes. The tabulated numbers represent the contents in cubic yards of a cutting, the length of which is 1 chain or 66ft., to the formation width and slope stated at the head of the table. At the commencement of the book there is a page devoted to instructions for using the tables, and several examples are given. These instructions are very clear, and they enable the reader quickly to grasp the method of using.

Diagrams of Connections for Storage Batteries. London: The Tudor Accumulator, 119, Victoria-street, S.W. Price 5s.—The diagrams given in this book show very clearly the various methods of connecting up storage batteries when used on electric lighting and power installations. The diagrams given cover most cases met with in practice, some showing very simple methods of wiring, while others are somewhat more complex, as, for example, where motor driven boosters are used. The connections shown in these diagrams are printed in red and blue, which enables the positive and negative leads to be followed without risk of confusing them.

The Elements of Electrical Engineering. By Tyson Sewell, A.M.I.E.E. London: Crosby Lockwood and Son, 7, Stationers' Hall-court, Ludgate-hill. 5s. net.—One of the main changes which have been made in this book since the previous edition is that descriptions are now included of some of the latest forms of arc and incandescent electric lamps, including flame arc lamps, Nernst, tantalum, osmium, mercury vapour, and other incandescent lamps. Another new feature is that the three-wire system of distribution is dealt with in an additional appendix. The whole work has been revised.

BOOKS RECEIVED.

Anleitung für die Herstellung und Justierung Geodatischer Instrumente. By Ing. Dr. Thordor Dokulil. Berlin: Verlag der Administration der Fachzeitschrift Der Mechaniker (F. and M. Harrwitz), Nikolassee bei. Price M. 5·50.

Formule Relative à une Condition de Stabilité des Automobiles. By Georges Marié. Paris (VI.): H. Dunod et E. Pinet, Editeurs, 49, Quai des Grands-Augustins. Price 2f.

Les Oscillations du Materiel des Chemins de Fer. By Georges Marié. Paris (VI.): H. Dunod et E. Pinat, Editeurs, 49, Quai des Grands-Augustins. Price 2f.

Les Oscillations du Materiel dues au Materiel Lui-même. By Georges Marié. Paris (VI.): H. Dunod et E. Pinat, Editeurs. Price 4f.

Lehrbuch des Gewerblichen Rechtsschutzes. By Prof. Dr. A. Osterreeth. Leipzig: A. Deichert Sche Verlagsbuchhandlung Nachf (Georg Böhme). Price M. 1·50.

The Canterbury Puzzles and Other Curious Problems. By Henry Ernest Dudeney. London: William Heinemann, 21, Bedford-street, W.C. Price 3s. 6d.

Les Oscillations du Materiel et la Voie. By Georges Marié. Paris (VI.): H. Dunod et E. Pinat, Editeurs, 49, Quai des Grands-Augustins. Price 2f.

Annuaire pour l'An, 1908, *Publie par le Bureau de Longitdues.* Paris: Gauthier-Villars, 55, Quai des Grands-Augustins. Price 1·50f.

The Law of Master and Servant. By T. C. Jackson, B.A., LL B. London: Macdonald and Martin, 6, Essex-street, W.C. Price 2s. 6d. net.

Die Drahtlose Telegraphie im internen Recht und Völkerrecht. By Dr. F. Meili. Zürich: Art Institut, Orell Füssli.

PORT OF PARA.

ON Saturday, November 16th, 1907, the anniversary of the declaration in Pará of the Brazilian Republic, the new works of the Port of Pará, were officially started amidst public rejoicing and in the presence of a large and influential assembly. The ceremony consisted of making the first concrete block for the new quay wall, and formally starting the two new large dredgers which were recently constructed and sent out to the Port of Pará. The bucket ladder dredger, the David Campista, was started by the representative of His Excellency Dr. Augusto Montenegro, Governor of the State of Pará; and the suction dredger, the Miguel Calmon, by Senator Dr. Antonio Lemos, Intendente of the Municipality. The officials and guests were afterwards conveyed three miles down the river to the Port of Pará Company's blockyard and works at Val-de-Cães, in two specially chartered steamers, where the first concrete block, weighing 45 tons, was made. In this block was embedded a marble case containing the customary newspapers and coins, &c. Presentations, speeches, and luncheon followed, after which the guests returned to the city by steamer.

The first section of the new port works, which is now being undertaken, comprises the construction of 1500 lineal metres of deep quay wall on the east bank of the Pará River, skirting the city; the dredging of a channel 1000ft. wide in front of the quay wall to a depth of 30ft. below mean low-water level, and also an entrance channel 650ft. wide towards the mouth of the river, with a depth of 26ft. below mean low-water. The project also includes the construction of fully-equipped modern warehouses, fixed and movable electric cranes, tramways, lighting installation, electric power-house, coal depôt, inflammables depôt, drainage works and buildings for Custom-house, national telegraph, post-office, administration offices, and such other works as may be necessary for the development of the port. The cost of the first section of works will be approximately 1¾ millions sterling.

The work is being carried out by the Pará Construction Company, with Dr. Elmer L. Corthell, M. Inst. C.E., as engineer-in-chief. The resident engineer and representative of the company at Pará is Mr. Ian Berry; the associate resident engineer is W. Garneys Wales, Assoc. M. Inst. C.E. The contractors for the quay wall and dredging are Messrs. S Pearson and Son, Limited, of London; while the contractors for the superstructural work are Messrs. Schneider and Co. of Paris.

THE TELTOW CANAL.

FOR many years it has been the intention of the authorities to do away with the necessity for the barge traffic between the rivers Oder and Elbe, passing through Berlin. So far back as 1861 the first scheme for a canal for carrying this into effect was suggested, and the canal has now been made. It was begun in 1901, and has now been some time in operation. The Teltow Canal, as it is called, whilst shortening the distance from the Elbe to the Upper Oder by 15 kiloms., and the journey from the Elbe to the Upper Sprey by 13 kiloms., was chiefly constructed to overcome the difficulties encountered in draining such Berlin suburban districts as are situated to the south and west of the metropolis. A map, showing its course, is illustrated in the engraving, Fig. 1. Starting at the Glienicker Lake, the canal traverses the Lake of Grienbnitz, from the upper end of which it follows the Beke Valley, and after crossing two roads and three double-track railways, it passes through the only lock which it has been found necessary to construct. This is situated at Machnow. The canal then passes through the villages of Lichterfelde and Steglitz, and after crossing the High Selton, continues its course through the western plains of the river Sprey, traversing a number of Berlin suburban districts.

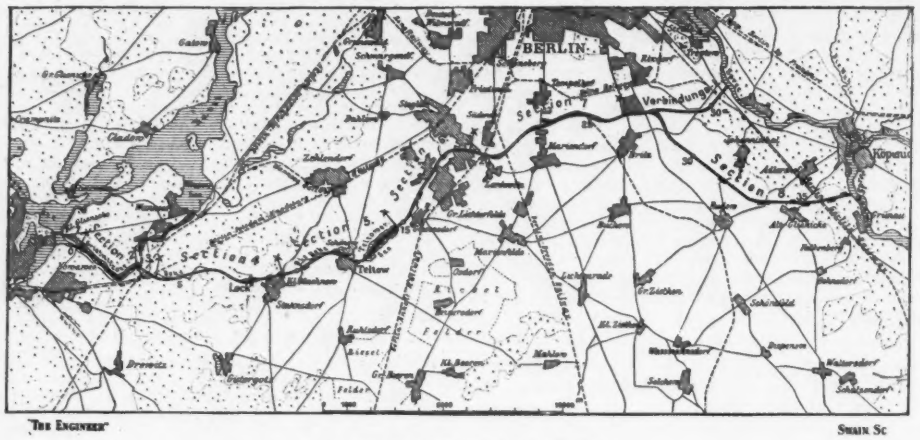


Fig. 1—ROUTE OF THE TELTOW CANAL

The cross section of the canal is given in Fig 2. It has a breadth at the bottom of 20 m. (65·6ft.), and a depth of 2·5 m. (8·2ft.) in the centre when the water is at its lowest point, and 2·1m. (6·9ft.) at the sides, 32·8ft. from the centre line. Below water level the banks have a slope of 1 in 3, and above the water 1 in 1·5 or 1 in 1·135, the latter employed depending upon the strength of the soil. There is a path 2 m. in width on each bank, which is 1·5 m. above high-water level. The breadth of the canal at the surface of the water is about 32 m.—say, 105ft.—when the water is at its lowest level, and when the curvature is less than 1000 m.—say, 3280ft.—in radius the bottom of the canal has been widened.

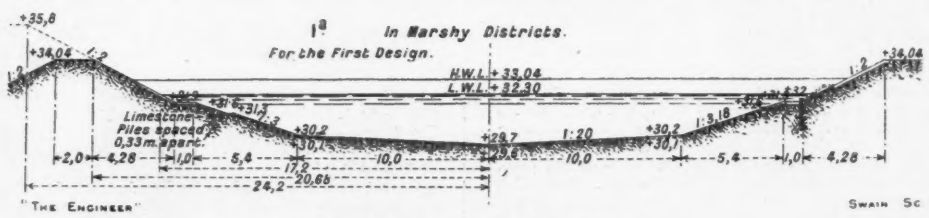


Fig. 2—CROSS SECTION OF THE CANAL

It is interesting to note that, in connection with the main canal, no less than eight railway bridges and thirty-seven viaducts have been constructed, whilst the branch to the Sprey includes another railway bridge and six viaducts, and the Prince Friedrich Leopold Canal another three viaducts. All the bridges, with one exception, have steel superstructures.

The lock, which we have already mentioned, is of exceptional design, for not only is it provided with syphons for filling and emptying it, but there are special lifting gates and capstans for facilitating the entry of vessels. All the mechanism is electrically operated. A plan of the lock is given in Fig. 3. As will be seen from the engraving, there are two locks parallel to each other, each being connected to the upper and lower canals by conduits 2·46 square metres in cross section, which are placed on both sides of each lock. Filling and emptying is effected, not by means of sluice gates, but by circulation pipes or passages, which are constructed in the walls of the lock on both sides, and these pipes are in communication with the upper and lower canals. There are altogether nine communicating entrances into each lock, so as to ensure uniform filling of the latter. The locks are shut off from the upper and lower canals and from each other by syphons constructed on the Hotopp system.

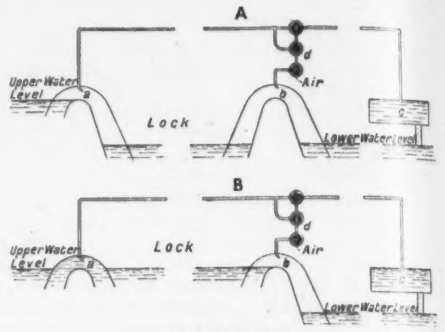


Fig. 4—SYPHONS

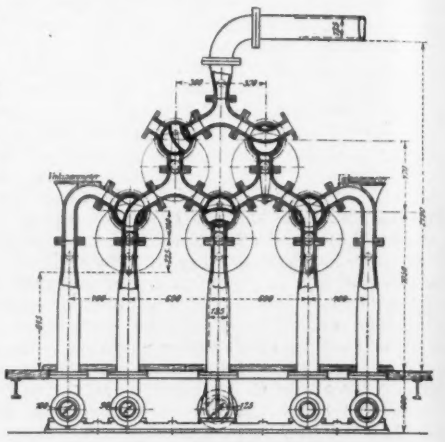


Fig. 5—SYPHON VALVES

The working of these syphons is as follows:—Outside the lock there are two suction bells *c*—Fig. 4—or cylindrical air-tight vessels, from the under-side of each of which a pipe passes down to beneath the surface of the water in the lower canal. These bells are always kept full of water, in a manner which will afterwards be made clear, and they are used for exhausting the air from the syphons *a* and *b*, the exhaustion being brought about by the sucking action of the water passing from *c* to the lower canal level. These bells are connected by means of pipes and controlling valves *d* to the summits of syphons *a* and *b*, placed respectively at either end of the lock.

The action of filling and emptying the lock will be readily understood by means of the engraving—Fig. 4—

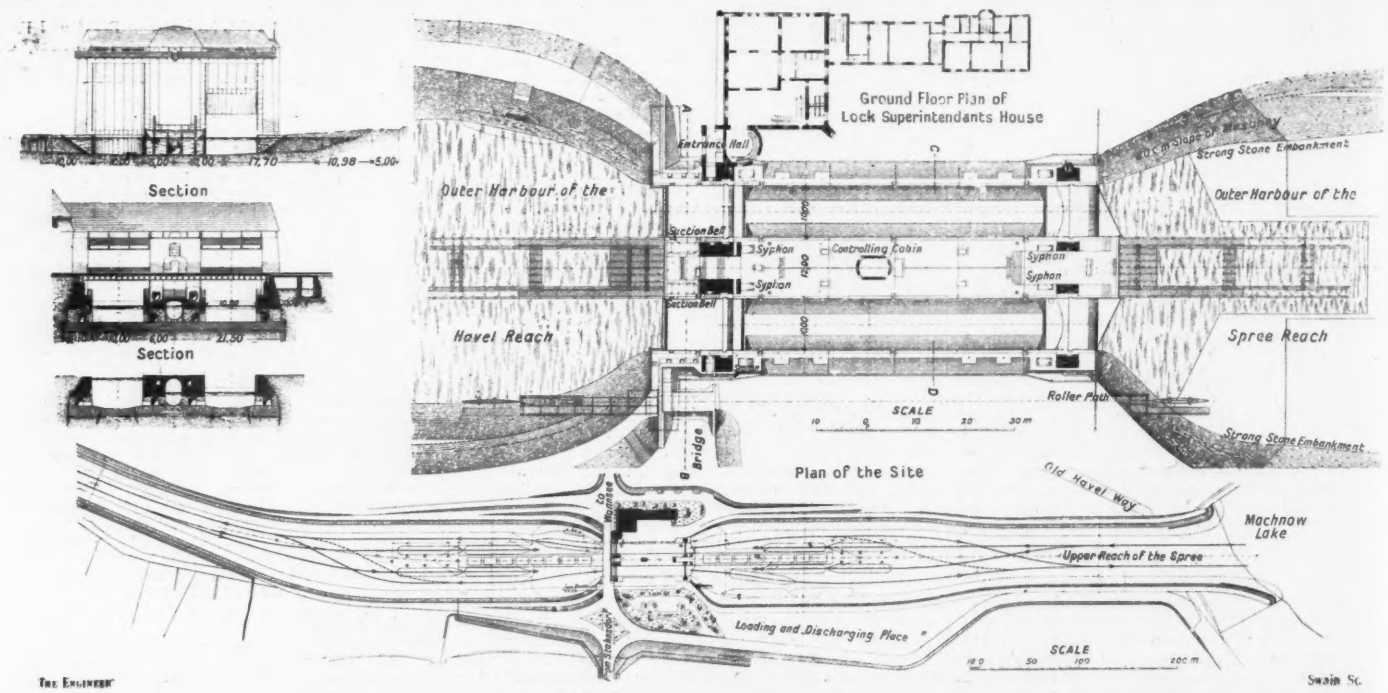


Fig. 3—LOCKS ON THE TELTOW CANAL

which, of course, is only diagrammatic. The upper diagram A shows the water in the lock at the level of the water in the lower canal. The air pressure in the syphon a is that due to the atmosphere. Suppose now that it is desired to raise the level to that of the water in the upper canal. By means of one of the valves at d the suction

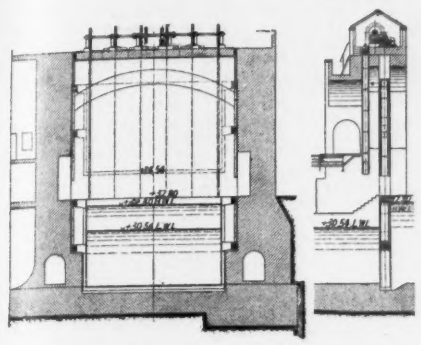


Fig. 6—LOCK GATES

vessel c is connected to the syphon a. Immediately the water in c begins to fall, and as it does so it draws with it the air in the syphon. The result is that a vacuum is formed which causes the lock water to rise in the syphon till it actually fills it, and syphonic action is set up. The water then flows from the upper canal into the lock until the levels in the two are equal. The flow of the water is used to re-draw the water up into the bell c. For this purpose the nozzle of the pipe entering a is bent in the direction of flow, and the air which was sucked by c from the syphon in the first instance is drawn back again and passes away with the water into the lock till the desired amount of water has entered c, when the communicating cock at d is shut. The bell c is then again ready for exhausting another syphon. When the level of the water

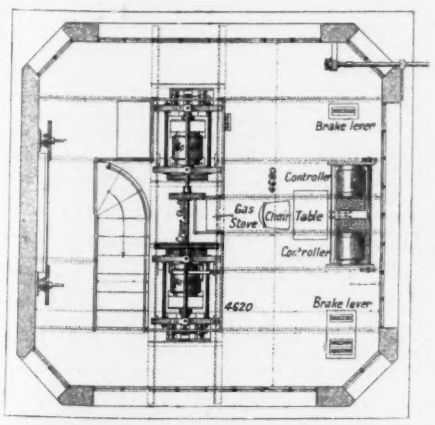


Fig. 9—APPARATUS FOR LIFTING GATES

in the lock is the same as that in the upper canal, the condition of affairs is that shown in diagram B, Fig. 4. When it is desired again to empty the lock the syphon b is connected through the valves d with the syphon a. As soon as this is done the water in a falls and sucks with it the air from b. Should this not be enough to set up syphonic action in b, recourse is had to the suction bell c, and then the action goes on just as above described until the level of the water in the lock has been reduced to that in the lower canal. The actual arrangement of the valves for controlling the syphons and suction bells is shown in Fig. 5.

A pump of one cubic metre per second capacity has been put in to carry the water used in the lock back into the river Spree when the water is low. The locks are closed by large vertical gates—Fig. 6. These gates are kept tight by means of pine wood planks screwed to the frame of the gate, they being forced against the recess in the granite by the water pressure. The gates are made with a horizontal framework, to which mild steel plates are riveted. The lower gates are 20 tons and the upper gates 16 tons in weight, each gate being counterbalanced. The mechanism erected for lifting the gates is illustrated in Fig. 9. It consists of an electrically-operated winch arranged as shown in the illustration. The shaft which carries the pulleys extends across the gate. Each gate and counterweight is suspended by two chains and four steel ropes. Provision has been made in order that the ropes, in the event of the chains breaking, may safely carry the gates and counterweights. The winch is driven by a 15 horse-power alternating current motor, the speed being 600 revolutions per minute. This motor will lift the gates to a height of 8·27 m. in one minute, and when in their raised position the gates are secured by bolts. Each lock has in its switch-room a special switchboard on which are two electrically operated level gauges—showing the exact position of the gate—and a maximum cut-out and ammeter have also been provided. A centrifugal cut-out, which brings a magnetic brake into operation, has been fitted to prevent damage to the motor should its speed for any reason become excessive.

The outlet channel in the central wall between the two locks at the upper end of the lock is closed by an adjustable gate which has a vertical motion. This channel is intended for passing excess water down to the lower canal level without its having to pass through the locks.

Boats arriving at the locks are first secured to the travellers which run along the wooden piers shown in

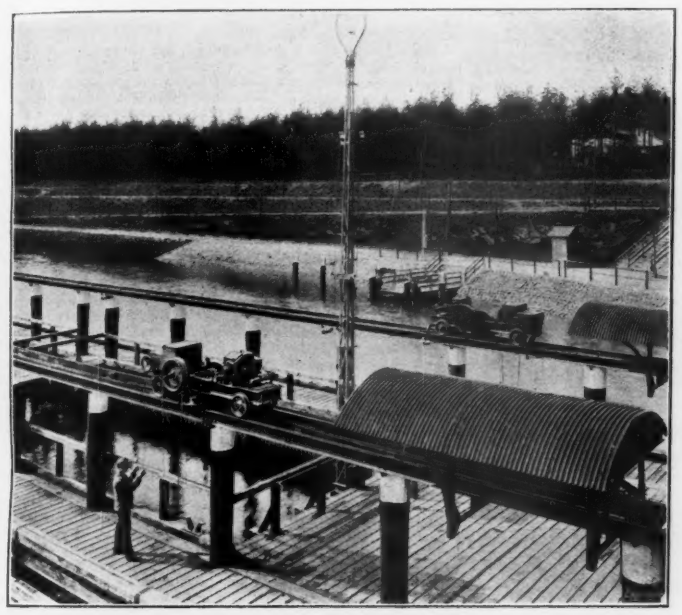


Fig. 7—HAULING TRAVELLER

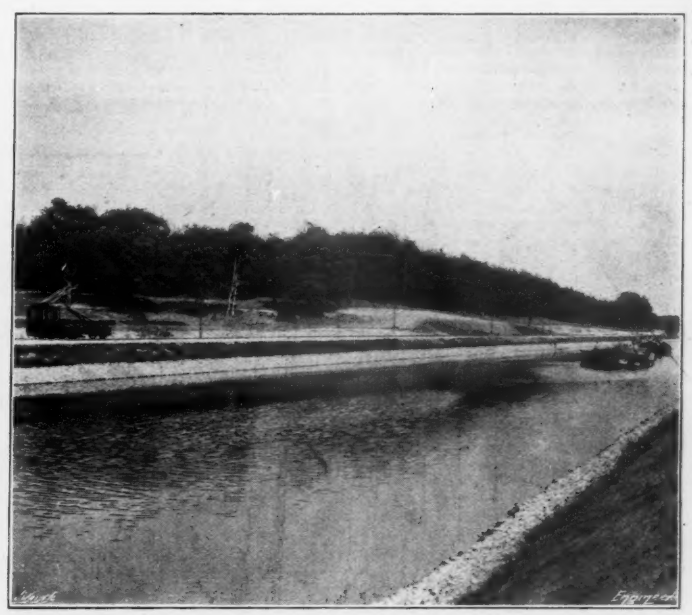


Fig. 8—ELECTRIC TOWING LOCOMOTIVE

Fig. 7, and are then towed into the lock. The traveller is propelled by a 11 horse-power direct current motor which runs at 1050 revolutions per minute along a fixed chain. This motor is capable of hauling the largest barges at a speed of 1 m. per second. The current is collected by the traveller as it moves along. The travellers are worked by special assistants who, after opening the gates, and as soon as a free course is indicated by the signal on the gate, turn the current on and allow the travellers to draw the barges into the lock. It is urged in favour of the travellers that no long tow ropes are necessary, the labour to operators thereby being considerably diminished. The lock master's house is shown in Fig. 3. From here he controls all the operations and signalling, &c. The state of the syphons and suction bells is recorded by means of a quadruple mercury vacuum gauge fitted near the regulators in each compartment. The average time required for a boat to pass in and out of the lock is fifteen minutes. Allowing an average of 400 tons to be conveyed by a standard boat or two Finow barges in passage through the lock, the two locks during ten hours working in the course of a day are capable of dealing with a total number of 3200 tons.

The adoption of mechanical means for hauling the barges throughout the length of the canal was considered to be indispensable, owing to the considerable volume of traffic. Towing steamers were used at first, but were not found to be efficient, owing to the narrowness of the waterway, and therefore haulage by means of the electric locomotives was adopted. The electric locomotives were designed to be able, on a level track of 1 m. gauge, to haul a train of two standard barges of 600 tons each, or four Finow barges at a speed of at least 4 kiloms. per hour, and one of the locomotives used on the canal is illustrated in the engraving, Fig. 8.

As the canal crosses two large lakes, *i.e.*, the Griebnitz and Macknow lakes, on which the use of electric locomotives was out of the question, a tugboat had to be requisitioned. One tugboat which was tried is illustrated in Fig. 10. It had three screws driven by electric motors, which derived their energy from an overhead wire arranged on the Lombard-Gérin system, which was originally intended for vehicles on ordinary roads.* It will be noticed that the tug was divided into six compartments, three of which contained storage batteries. Each battery consisted of 220 cells, having a capacity of 244 ampère-

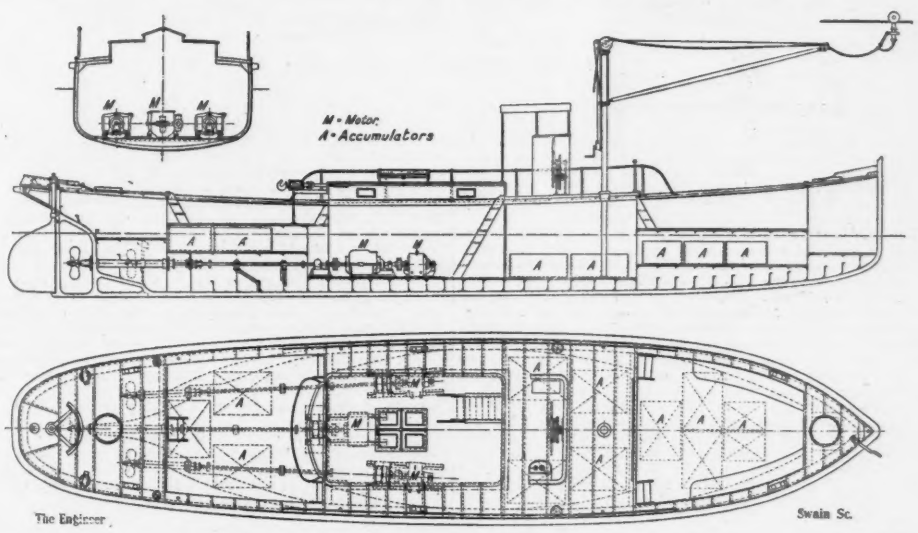


Fig. 10—ELECTRIC TUG BOAT

hours with a continual discharge of five hours. The total weight of this battery was 11,000 kilos. One of the compartments contained three series-wound motors, each of

* See THE ENGINEER for March 14th, 1902.

which was direct-coupled to a propeller shaft. The central motor developed 25 horse-power, while the two on the outside developed 20 horse-power each. It was found, however, that the boat was not at all economical, as the current consumption alone was three times that of the locomotives. Trials were also carried out with an alcohol-engine barge, but here again the trials were not successful.

Finally, an ordinary tug, fitted with steam engine and a boiler which was fired with heavy tar oil, was found to be quite satisfactory and was adopted. The burner is designed on the Körting system, and consists mainly of a nozzle in which the oil has been atomised under pressure and is thrown out in a fine spray. It is claimed that this arrangement was improved upon by fitting a preheater designed by Regierbaumeister Erich Block, so as to ensure a perfectly smokeless combustion and most economical fuel consumption. The boilers were fitted with superheaters on the Schmidt system, and the consumption of oil was found to be about ·5 kilos. per horse-power hour, which, in the case of an oil costing 3·4 marks per 100 kilos., works out at about 1·7 pfennig. Therefore, on this basis, the cost of oil, taking the load at 1200 tons and the speed at 4 kiloms., for each ton-kilometre would be ·04 pfennig.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE USE OF SUPERHEATED STEAM IN LOCOMOTIVES.

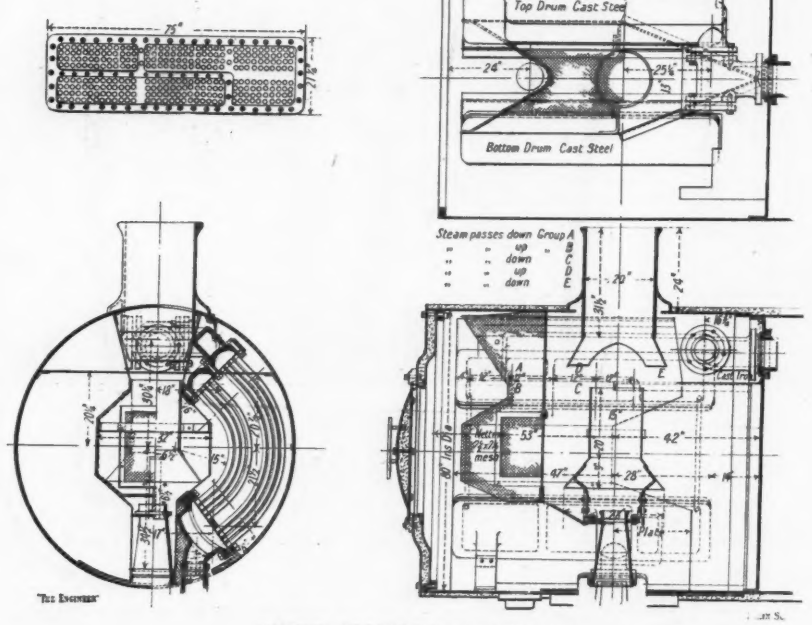
SIR,—At the conclusion of your recent interesting article on the "Application of Highly Superheated Steam to Locomotives," there is given a short account of the superheater which is being employed by the Baldwin Locomotive Works. As the author confesses ignorance of the results which have been obtained with this device, it may be of interest to your readers to give particulars of some tests which have been recently carried out on a Baldwin superheater locomotive on the Chicago, Rock Island, and Pacific Railway.

Before giving the results of these tests, however, I should like to correct the author's account of the development of the Baldwin superheater. He says: "In the first engine to which it was applied, a heavy 2-10-2 locomotive, the cylinders were 32in. diameter and stroke, and steam at only 130 lb. was used . . . . Later the pressure was raised to 150 lb., notwithstanding the size of cylinders, in order to obtain the necessary duty. In a later engine the cylinders have been reduced to 28in., with 32in. stroke, and the initial pressure has been raised to 160 lb."

The facts are that the first engine to which the Baldwin superheater was applied was one of the series of tandem compound 2-10-2 locomotives for the Atchison, Topeka, and Santa Fé Railway, of which particulars are given on pages 254 and 255 of your issue of Sept. 13th, 1907. These engines have about 237,000 lb on the coupled wheels, which are 4ft. 9in. diameter, and, as originally built, without superheaters, had tandem compound cylinders, of which the high-pressure were 19in. diameter, and the low-pressure 32in. diameter, with 32in. stroke, the boiler pressure being 225 lb. per square inch. As an experiment on one engine, a superheater was applied, the high-pressure cylinders being omitted. It was calculated that a boiler pressure of 130 lb. would be sufficient with the 32in. cylinders, but to give an ample margin of reserve power the safety valves were set at 150 lb. per square inch. The results obtained with this engine were so satisfactory that the Atchison, Topeka and Sante Fé Railway ordered a considerable number of new locomotives to be equipped with Baldwin superheaters, and other railroads have followed their example. Among these is the Chicago, Rock Island and Pacific Railway, of which locomotive No. 1799 is presumably the engine to which the author of your article refers as having cylinders 28in. by 32in. and 160 lb. boiler pressure. The details of the superheater are shown in the accompanying drawing.

The main dimensions of this locomotive are:—

Cylinders—	
Diameter	28in.
Stroke	32in.
Driving wheel diameter	5ft. 3in.
Boiler pressure	163 lb. per sq. in.
Weight on coupled wheels	210,000 lb.
Total weight of locomotive	237,000 lb.
Heating surface—	
Fire-box	179 sq. ft.
Boiler tubes	3658 sq. ft.
Total exclusive superheater	3837 sq. ft.
Superheater	756 sq. ft.
Total, inclusive superheater	4593 sq. ft.
Grate area	60·2 sq. ft.
Boiler, smallest inside diameter	80in.
Boiler tubes—	
Number	443
Outside diameter	2in.
Length	15ft. 9in.
Tender capacity	7500 (mo. gall.
Weight in working order (about)	160 000 lb.



BALDWIN LOCOMOTIVE SUPERHEATER

In August of this year an extended series of tests were carried out on the C.R.I. and P. Railway. One set of tests was made between Blue Island and Silvis, on the Illinois division, a distance of 158 miles, and a second set between Dalhart and Tucumari, a distance of 93·5 miles, on the El Paso division. On the Illinois division the maximum grades encountered are 1 in 180 going east, and 1 in 160 going west. On the El Paso division, in both directions, the maximum grade is 1 in 100.

Six runs were made over each division in freight service, the coal and water being measured and the locomotive indicated every five or ten minutes to determine the horse-power. The average results obtained on these tests are shown below:—

	Illinois	El Paso
Division of road		
Number of cars	45 loaded + 25 light	37 loaded + 2 light
Weight of train exclusive of engine and tender	2380 tons	1638 tons
Number of stops	14·7	3·8
Time in stops	3 h. 16 m.	1 h. 33 m.
Running time	9 h. 41 m.	4 h. 56 m.
Running speed	16·1 m.p.h.	15·5 m.p.h.
Indicated horse-power	822	892
Water per I.H.P. per hour	27·5 lb.	22·6 lb.
Coal per I.H.P. per hour	4·23 lb.	3·86 lb
Boiler pressure	154 lb. per sq. in.	160 lb. per sq. in.
Superheat from indicated admission pressure	49 deg. Fah.	56 deg. Fah.
Length of run	157 miles	74·5 miles
Coal fired per square foot of grate per hour	58 lb.	55 lb.
Water from and at 212 deg. Fah. per lb. coal	7·86	7·54

These results may be compared with those obtained in similar tests made last year on the Illinois division with two saturated steam locomotives of the ten-wheeled (4-6-0) type. Of these one was a Vauclain balanced compound, and the other a single-expansion. The balanced compound took trains averaging 1600 tons weight over the division at a running speed of 20·2 miles per hour, the consumption per indicated horse-power per hour being 29·3 lb. of water and 5·24 lb. of coal, while the averages for the single-expansion were: train weight, 1504 tons; running speed, 19·5 miles an hour; water, 33·6 lb.; and coal, 6·02 lb. per indicated horse-power per hour. The three series of tests on the Illinois division show the water consumption of the superheater to be 6 per cent. less than that of the compound, and 18 per cent. less than that of the single-expansion saturated steam locomotive. On the El Paso division, where the conditions were such as to give a slightly higher degree of superheat, the results were even more favourable, the water consumption of the superheater being only 22·6 lb. per indicated horse-power. To compare with this may be taken the results obtained at the St. Louis testing plant with saturated steam consolidation locomotives under the most favourable conditions. The Pennsylvania standard consolidation No. 1499, with a boiler pressure of 205 lb. per square inch, showed an average water consumption of 25·2 lb. per indicated horse-power, while the Lake Shore and Michigan Southern consolidation No. 734, with a boiler pressure of 200 lb. per square inch, averaged 25·8 lb. per indicated horse-power. That is about 11·4 per cent. in favour of the superheater with a boiler pressure of 160 lb. per square inch.

These figures point clearly to the conclusion that the Baldwin superheater, giving about 50 deg. Fah. of superheat at the admission pressure, is capable of effecting savings of about 15 per cent. in water and 10 per cent. in coal, in comparison with an ordinary single-expansion saturated steam locomotive.

LAWFORD H. FRY.

THE PRINCIPLES OF MECHANICS.

SIR,—Mr. Sydney A. Reeves writes to explain the differences between himself and me, and enumerates seven propositions whereby to make his position clear and definite. But in general terms I agree with all these seven propositions, although the subclauses of some of them require comment or correction. His (1) and (2) I agree to without reservation. His (3) is ambiguous, and, taken either way, is incorrect except for very special and improbable relations of mass and velocity. If each of the particles of his system is to be paired to every other, the sum of the kinetic energies of approach between all such pairs is in excess of the total internal kinetic energy of the system; if each is paired only with one other, then the sum for all such pairs falls short of the true total. Regarding (4) to (7), all that need be said is that I have not at any time referred to any "disembodied base," and that I, like many others, believe that all our geometrical notions solely and wholly relate to, and are derived from, our knowledge of the relative positions of different portions of matter—possibly in the future to include the ether if discoveries regarding radiation lead that way. But at the same time I may note that Mr. Sydney Reeves does not seem to recognise that it requires a minimum of *three* mass-centres to constitute or define a geometrical base, or, as we here prefer to term it, a geometric field. Such a field may, however, also be defined by reference to any number of masses.

Mr. Reeves complains that I introduce "gratuitous complexity" by referring to the energy absorbed by elastic deformation, &c.; but how is it possible to consider kinetic energy in connection with conservation of energy without doing so, since we know that at every turn kinetic energy is transformed into these other kinds?

Mr. Reeves still complains of the basic formula $\frac{1}{2} m v^2$ being taught "without warning that it is an approximation" only; but he has produced no argument in favour of his idea that it is an "approximation." I presume that, still speaking in terms of kinetic energy, he acknowledges the truth of the elementary proposition that the total energy—relatively to any geometric field fixed by any three mass centres—equals the sum of the internal and the external energies. If he properly understands the meaning of this proposition, I am unable to see how he can defend his assertion that $\frac{1}{2} m v^2$ is an "approximative" measure, by which phrase is evidently implied that the measure contains, covers, and hides some error.

But I cheerfully agree that the $\frac{1}{2} m v^2$ of any mass m is always no more than the contribution of this mass to a sum total of kinetic energy which exists only as a velocity relationship between a plurality of masses of which m is one, and that the contribution of one of them cannot exist without the co-existence of other similar contributions from the other masses of the system.

December 16th. ROBERT H. SMITH.

THE VIBRATION OF SHIPS.

SIR,—I have read with interest all that has appeared in your pages about the two new Cunard ships. It appears to me that Professor Smith has not had any practical experience of the casting of bronze propeller blades. He thinks it possible that they may have cavities in them, and that, in consequence, their shapes must be untrue if their weights come out right. On the other hand, using the same argument, if the shapes are right there can be no cavities.

Now, I can assure Professor Smith that the casting of bronze propellers has been reduced to a fine art. The uniform density of the metal is assured, and for all fast work the surfaces of the blades are not only made quite smooth, but they are highly polished—a well-known and most important condition, as may be well imagined when it is remembered that the velocity of blade tips through the water may reach 70 miles an hour.

Let us now come in board and ask if the turbine rotors are ever really in balance. No one can tell. They are far too big and too heavy for practical testing. But I know that tremendous difficulties are encountered in balancing small turbines for driving dynamos on board ship. The balancing is done by putting shot into small cavities made to receive them in the rotor. The process is one of trial and error. The rotor is in place, and the cover has to be lifted every time shot has to be added or taken away. The great trouble is that perfect balance at one speed is not perfect balance at another, because of the change in the place of the centre of the gravity due to the unequal expansion of the rotor under the influence of centrifugal force. Now, if the rotor is out of balance in such ships as the Mauretania, we have one cause of vibration suggested.

My own view is, however, that of your correspondent, Mr. Richard Slater. The rudder is a principal cause of vibration. This is particularly manifested in torpedo boats. My experience on board these is that, while there is little or no vibration when the rudder is amidship, the moment the helm is shifted vibration begins. When the helm is put hard over, as in turning circles, the stern literally jumps, and the whole steering gear thrashes. This effect is much worse with twin screws than with single screws. It is due to the impact of the water thrown aft on the rudder.

I have been told—but I have no practical experience of the fact, if it be a fact—that by prolonging the boss of a propeller, forward and aft, in the shape of a solid of least resistance, an approximation to a parabolic spindle, with its major diameter just forward of the screw, vibration is much reduced. Perhaps some reader can give information on this point.

Liverpool, December 23rd. SUPERINTENDENT ENGINEER.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made at the Admiralty:—

Engineer Rear-Admiral.—C. J. North, to the Impregnable, additional, for service on staff of Commander-in-Chief, Devonport.

Engineer Commanders.—E. W. Cudlip, to the Vivid, for the Andromeda; A. R. Rolle, to the Europa, on recommissioning; S. Rawling, to the Barfleur, additional, for the Renown; J. E. Johnson, to the President, additional, for inspection of Whitehead torpedoes at Woolwich Arsenal.

Engineer Lieutenants.—A. J. C. Moore, to the Vivid, for the Andromeda; J. H. Fletcher and P. J. King, to the Europa, on recommissioning; J. S. Madden, to the Victory, additional, for four months' study in Spain; and J. Hamilton, to the Vivid, additional, for the Minotaur.

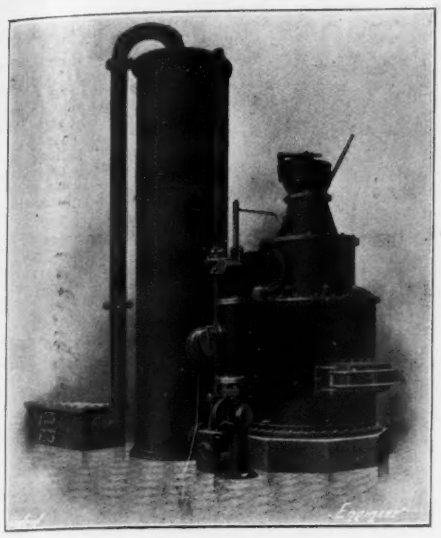
Engineer Sub-lieutenant N. Roberts has been promoted to the rank of Engineer Lieutenant on the permanent list, with seniority of December 1st, and re-appointed to the Pelorus, on promotion. Engineer Sub-lieutenant H. B. McGhie has been promoted to the rank of Engineer Lieutenant on the permanent list, with seniority of December 1st, and reappointed to the Encounter, on promotion.

Naval Instructors.—G. P. Edwards, to the Victory, for R.N. College, Osborne, and A. Cleve, to the Impregnable.

CRYSTAL PALACE ENGINEERING SCHOOL.—The "Wilson Premium," for the best paper read before the Crystal Palace Engineering Society during the present session, has been awarded by the Council to T. M. Bradley for his paper on "Tank Irrigation in India." Other papers read during the session were:—"Ferro Concrete," by W. E. Oliver; "Railway Construction in India," by A. L. Stuart William; and "Land Reclaiming," by E. C. Graham Jones. Mr. J. W. Teale, former student, also read a paper upon "Prospecting for Metals." The premium was presented to Mr. Bradley by Mr. T. Hurry Riches, M. Inst. C.E., president of the Institution of Mechanical Engineers, on the occasion of the 105th distribution of certificates of the above school on Friday, December 20th, at which he presided.

300 HORSE-POWER SUCTION GAS PLANT.

THE illustrations on page 652 represent an electric power plant which embodies the latest design of twin-cylinder producer gas engine, built by the National Gas Engine Company, Limited, Ashton-under-Lyne. As will be seen from the engravings, the cylinders are placed side by side so that each piston works on a separate crank; and the cranks being set 180 deg. apart, an impulse is given to the shaft at each revolution. The engine is designed to run at 150 revolutions per minute, and at this speed develops 300 brake horse-power, with producer gas of 130 to



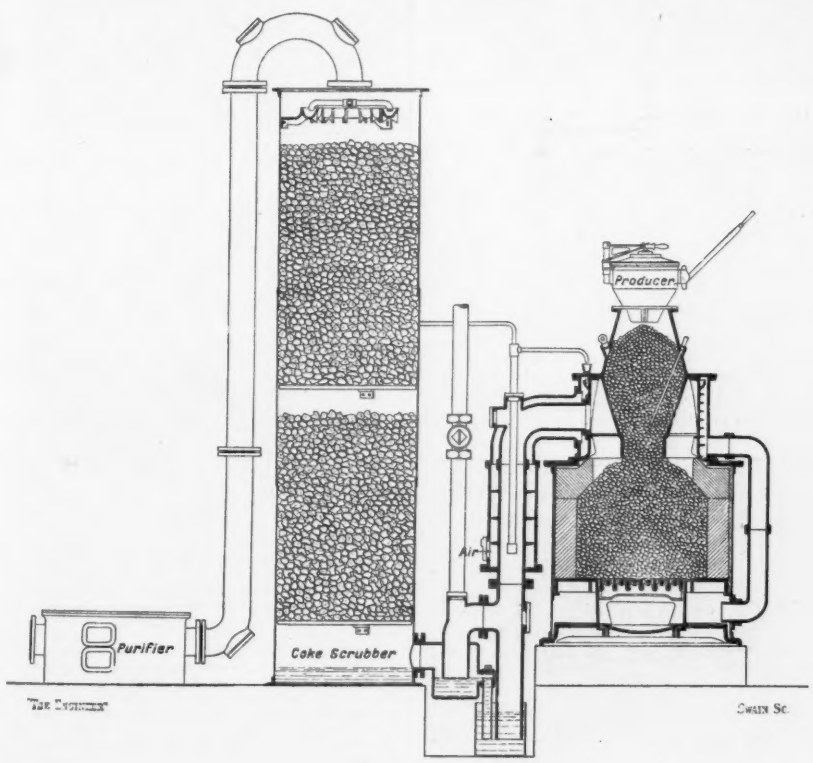
SUCTION GAS PRODUCER

140 B.Th.U. It is also capable of overcoming temporary overloads of 15 per cent. The cylinders are 24in. diameter by 30in. stroke, and have separate liners, which, together with the breech ends, are built into the back frame of the engine, giving a strong and rigid combination. Both the air and exhaust valves are fitted in the breech end, and are easily withdrawable for cleaning purposes—a highly desirable feature when using producer gas. The front end of the bed is of a strong girder form carrying three massive bearings provided with bronze steps and ring lubrication. The crank shaft is of Siemens-Martin steel forged solid throughout, the webs being cut out of the solid, and the whole machined and polished all over. The bearings are of ample diameter and length, and the crank webs are fitted with balance weights to secure steadiness of running. The induction and exhaust valves are actuated from the back motion shaft by means of cams with large bearing surfaces, the valve gear being both simple and strong. The connecting-rods are mild steel forgings, machined and of ample strength. They have adjustable bearings in halves at both ends, the bearings being made of a special mixture of bronze. The motion shafts are driven by skew gear worm wheels, with machine-cut teeth, and are carried in adjustable bearings, having bronze steps with ring lubrication.

A special motion shaft is run across the rear ends of the cylinders to operate the low-tension magneto apparatus, of which there are two sets, with separate plugs to each cylinder. The magneto motion shaft is driven by skew gearing from the side motion shaft, and the timing of the ignition can be varied simultaneously in both cylinders in an ingenious manner. The mechanism is arranged so that the wheel which drives the magneto shaft can be moved axially through a certain distance; and, since the teeth are at an angle, it follows that the relative angular positions of the magneto shaft and side motion shaft are altered according to the degree of axial movement imparted to the driving wheel. In this way a simple, strong, and accurate timing gear is provided which acts simultaneously in both cylinders. The governing device is also a new feature, and gives graduated impulses to suit the load on the engine. It is designed on the relay principle. A positive excentric motion operates the gear which actuates the air and gas regulating valves, and the governor simply selects whether the valves shall be opened or closed. The selecting apparatus worked by the governor actuates a double ratchet motion connected with the excentric, the result being that either one or both of the pawls are held out of gear. Consequently, the ratchet is caused to move in either direction or to remain stationary.

Frequent objections urged against the employment of large gas engines are uncertainty and difficulty of starting. The National Gas Engine Company has exercised great care in the provision of absolutely reliable starting mechanism. Compressed air at 80 lb. pressure per square inch is used for starting this engine, the air being introduced by means of two timing valves, one for each cylinder. These valves are positively operated by cams on the back shaft, which are thrown out of gear when the engine has commenced running. The timing valves are connected with automatic valves on the cylinder, and the starting operation is as follows:—The timing valve is put into gear; the gas cock is opened, and, finally, the compressed air is turned on by means of the receiver stop valve. Under the influence of the compressed air the engine starts up immediately, and a mixture of gas and air is drawn in on the suction stroke. Ignition of the charge takes place after about two impulses with compressed air, and the engine commences to work "on its own gas" An automatically closing valve on each cylinder prevents the exploded gases from being forced back into the compressed air valves, and hence it is possible to keep on the compressed air until the engine is running at its normal speed. In this way the engine may be kept running on compressed air if ignition of the subsequent charge fails, due to the presence of air in the gas pipes or for other reasons. The unsuitable mixture is thus drawn out, and it is perfectly safe for ignition to take place at any time while the supply of compressed air is maintained, the automatic valves previously alluded to acting as back-pressure valves on the working stroke. The pistons are lubricated by an automatic ram, pump driven from the back motion shaft. The barring gear is bolted to the engine frame, and arranged so that one man can easily move the crank shaft round to any desired position. One of these engines worked at the Dublin Exhibition for six months, coupled to a Siemens dynamo, and was one of the chief units for supplying light and power. In this set the dynamo was complete in itself, and coupled to an extension of the crank shaft by means of an Escher-Wyss type of flexible coupling.

For plants of over 150 horse-power the National Gas Engine Company recommends the use of two-cylinder engines, and the same practice is followed in respect of gas producers.



150 HORSE-POWER SUCTION GAS PRODUCER

Under these conditions, for short periods, each plant acts as a spare to the other, and thus elasticity in working is gained. In the 150 horse-power producers the generator body differs materially from that in the producer previously illustrated, being made of wrought steel plates. The ashpit is, however, of cast iron, to obviate the effects of corrosion. The sectional illustration above shows clearly the method of construction. The vaporiser is also made of cast iron, and the whole forms a substantial producer in which corrosion troubles are minimised. The vaporisation is effected on the same principle as the generation of steam in a flash boiler, and the amount of water fed into the vaporiser is regulated in accordance with the load. This secures the supply of the correct proportions of air and steam, the means adopted enabling the degree of saturation to be regulated at any time and under all loads, so as to give the best results. In the paper read before the Iron and Steel Institute recently on the "Use of Steam in Gas Producer Practice," by Professor Bone and Mr. R. V. Wheeler, the importance of the correct degree of saturation upon the calorific value of the gas produced was emphasised very clearly. It is claimed by the National Gas Engine Company that in its gas plants the combination of means for pre-heating the air with a flash boiler type of vaporiser enables the highest possible theoretical efficiency to be attained. As will be seen by reference to the sectional illustration, an ample coke scrubber is provided for cooling and washing the gas. The latter further passes through a combined impact and sawdust scrubber for removing the final traces of tar in the gas. It will also be observed that the construction of the ashpit and arrangement of the water seal pot are different from those fitted in the earlier patterns.

THE RAILWAY AGREEMENT.

As was anticipated, the proprietors of the Great Northern and Great Central Companies unanimously approved of this agreement at their respective meetings on Friday last, and steps are to be taken forthwith to obtain the consent of the Railway and Canal Commission. It is presumed that such consent will be obtained, and therefore the two lines are practically to be worked by a Joint Committee as from January 1st next. The first Chairman is to be Lord Allerton—now chairman of the Great Northern—and the Vice-chairman is to be Sir Alexander Henderson—now chairman of the Great Central. Lord Allerton is to remain chairman as long as he holds his position on the Great Northern, and is to be succeeded by Sir Alexander Henderson, provided that the latter still be the chairman of the Great Central. Mr. Sam Fay is to be the manager for the Joint Committee, and as soon as Mr. Oliver Bury can be spared from his present duties he is to join the Great Northern Board The reason for the exclusion of the Lancashire, Derbyshire and East Coast Railway and the Sheffield District Railway from the terms of the agreement were explained at the meeting. These lines were acquired by the Great Central a year ago, and when powers were obtained for this in 1905 certain statutory obligations were entered into, and there was a doubt as to whether the parties affected could be arranged with so that the acquired lines could be brought under joint control. Sufficient rolling stock and stores will be retained for use on the Lancashire, Derbyshire and East Coast and Sheffield District Railways, and the remainder will be placed at the disposal of the Joint Committee. The capital accounts will be kept entirely separate, and neither company will have any responsibility with respect to the other's capital account. The agreement does not interfere with the separate entities of the companies, and the dividends will be distributed out of the share of the net receipts as hitherto. There are certain funds, such as fire insurance, steamship insurance, and depreciation, and some sundry depreciation accounts on both sides, and these are placed by the two companies under the control of the Joint Committee. Lord Allerton, in concluding his speech at the Great Northen meeting, said that the interests of the nation are bound up inseparably with the railway conveniences of this country. The Government should realise that railway facilities could not be improved unless confidence in railway capital exists, and therefore that confidence in the railways is the very key-stone of the national prosperity. His lordship then added, "I believe that it will be found in the future that this view is held by important members of the Government. I believe that the movement which this agreement indicates is but one step—possibly the first step—in a movement which will grow and go on, and under which the railway facilities of this country will not be restricted, but will be improved, and, at the same time, by great economies a great saving of national waste will be avoided."

OBITUARY.

EDWARD FIRTH.

THE death is announced of Mr. Edward Firth, of Tapton Edge, Sheffield, and Birchfield, Hope, Derbyshire, in his seventy-eighth year. Mr. Firth, who had been in failing health for a considerable time, was a member of a family well known in connection with the development of the heavy steel industries of Sheffield. He was a son of the late Mr. Thomas Firth, and brother of the late Mr. Mark Firth, founders of the firm of Thomas Firth and Sons, Norfolk Works, Sheffield. He spent his early life in the business, and for many years was intimately associated with the growth of the great East End establishment. Although he retired from active service in the management of the firm as far back as 1880, he retained his seat on the directorate until ten years ago.

INSTITUTE OF MARINE ENGINEERS.—It has been arranged to hold a conversazione on Friday, January 24th, 1908. The King's Hall and Throne Room in the Holborn Restaurant have been engaged for the occasion. It is proposed to open the proceedings with a concert from 7 to 9 p.m., after which dancing will commence and be continued till 3 a.m. Simultaneously with the dancing, from 9 to 12, music and other means of recreation will be provided in the Throne Room.

MR JARDINE AND HIS WORKPEOPLE'S CHILDREN.—One evening lately the Mechanics' Large Hall, Nottingham, presented a most animated appearance, the occasion being the Christmas entertainment which is generously provided by Mr. Jardine, engineer of Nottingham, for the children of the workpeople at his various factories. This is the twenty-fourth year in succession that Mr. and Mrs. Jardine have entertained the children. This year they numbered 2500, which is the largest gathering that has yet been held. An enjoyable and varied programme had been arranged, including a number of cinematograph pictures, and these proved very amusing, and were much appreciated by the youngsters. A popular selection of music was rendered by Jardine's military band. At the conclusion of the entertainment Mr. Jardine addressed a few words to the children, after which Mrs. Jardine graciously presented each child with a piece of silver money, a bun, an orange, and a Christmas card. To this entertainment are also invited those people now employed at the works who, as children, attended the entertainment, and who have worked continuously for Mr. Jardine since leaving school.

NOTES ON THE MANUFACTURE AND UPKEEP OF MILLING CUTTERS.*

By Dr. H. T. ASHTON, Member, of Royal Small Arms Factory, Enfield Lock.

ALTHOUGH the system of manufacture of milling cutters detailed in this paper is suitable for general application, it has been developed more particularly to meet the difficulties of extending the use of high-speed steel to milling cutters of complicated shape, required when cutting to give an accurate finish and a good surface. It is believed that these difficulties have been commonly met with, and that, owing to them, the general introduction of high-speed steels of the Taylor-White class has, so far, generally proved of less benefit to engineers for milling cutters than for any other form of cutting tool used in engineering workshops.

Perhaps the advantages to be obtained by the use of high-speed steels for such cutters are also not so obvious as they are for the heavy lathe or planer tools, where the almost red-hot chips, that they can be made to produce, appeal to the least observant onlooker When, however, it is considered that this class of steel not only has the property of keeping a cutting edge for a reasonable time when taking very heavy cuts at a previously unattainable speed, but also keeps its cutting edge when used with a moderate cut and speed for a far longer period than was previously obtainable, its advantages, if applicable to complicated milling cutters, are clearly just as great as for the simpler tools taking the heavy cuts. For, although the nature of the work upon which the cut is taken and the finish required from the cut may not allow, in the case of the milling cutter, any great increase of speed or feed by the use of high-speed steel, and, consequently, little direct saving upon the time occupied in doing the work, as in the cases of the other classes of tools, yet an equally important saving is effected upon the cost of supply of the tools themselves. The milling cutter is the most expensive of all the tools used by engineers in cutting metals. In the simplest milling cutter the cost of workmanship so largely exceeds the cost of material that a moderate increase of life obtained by improvements in the raw material far outweighs a considerable increase in its original cost, provided that there is sufficient work in sight for the cutter to ensure its being fully employed for its maximum possible life. Perhaps it is this ruling condition which has led to somewhat less attention being paid to the application of these steels to milling cutters in general engineering workshops than to other cutting tools. For in these, with the exception of a few simple cutters generally useful for roughing out or for finishing simple profiles

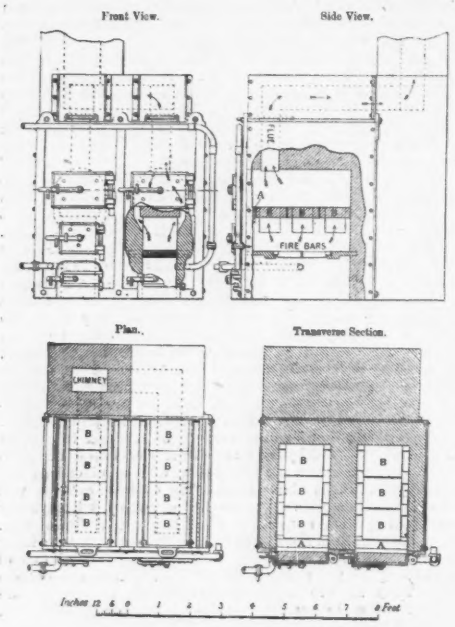


Fig. 1—HARDENING FURNACE

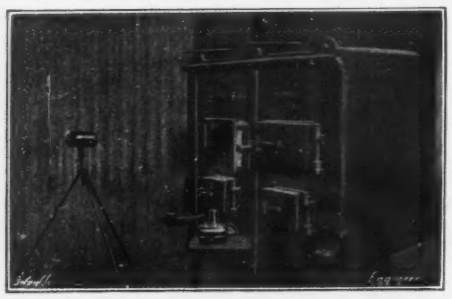


Fig. 2—HARDENING FURNACE AND PYROMETER

likely to recur, it has perhaps generally been more economical to make the cutters from ordinary qualities of tool steel, or even, in some cases, from case-hardened mild steel; hence the preparation of an elaborate milling cutter from high-speed steel has not received quite the same general attention as the preparation of other cutting tools of maximum endurance.

The case, however, is different in a number of workshops where the interchangeable parts of many classes of apparatus and fittings depend very largely upon the use of formed milling cutters, and where the accuracy of the work so produced is directly dependent upon the accuracy with which the form of the cutter can be maintained for a prolonged period. It is desirable also that the cutters should have as long a life as possible in actual service not only to minimise the first cost and upkeep, but also to keep the output of the machines as continuous as possible, by reason of freedom from delays in changing the cutters. These points depend chiefly upon:—(1) The quality of steel from which they are made. (2) The method of hardening adopted. (3) The care and accuracy with which the new cutters are made. (4) The facility and correctness with which the cutters can be ground up when they have become dull or lost their accuracy.

(1) *The steel used*.—There is, of course, nothing to compare with the recently developed high-speed steels as a material for cutters which are required to work at a high cutting speed and have the maximum possible life; and no difficulty is now experienced in obtaining work with a sufficiently satisfactory finish, provided care is exercised in the grinding and finish of the cutters, in the manner which will be described, and also if the cutting speeds and feeds are suitably arranged. Any of the best-known makes of this class of steel can be used in conjunction with the system to be described. The cutter blanks are annealed, packed in spent powdered charcoal and steel turnings in cast iron pans with covers which are luted down. These are placed in the annealing furnace first thing in a morning and are gradually heated up to 700 deg. Cent. to 750 deg. Cent.; this heat is usually reached by 1 o'clock

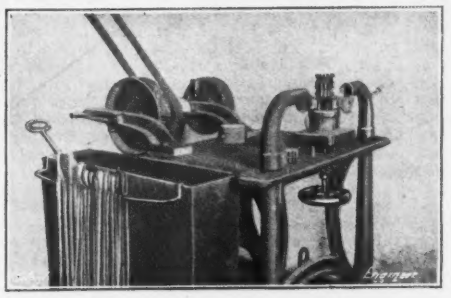


Fig. 3—AIR-HARDENING TABLE

and is maintained until about 5 o'clock, when the dampers are closed and the furnace is allowed to cool gradually for forty-eight hours. It is found that some makes of high-speed steel are satisfactorily annealed by the makers, but it is not the universal practice. Annealing in this manner is found to give thoroughly satisfactorily results.

(2) *Method of hardening*.—The furnace used for hardening cutters is shown in Fig. 1 and Fig. 2, and it has been found specially adapted for obtaining a soaking heat, together with the high temperature necessary in treating this class of steel and freedom from oxidation. The furnace is coke fired and has a forced draught, and temperatures up to 2300 deg. Fah. can be obtained. In using the furnace the cutters are packed closely in powdered charcoal in sheet steel boxes about 6in. by 6in. by 3in. These boxes take from 2½ to 3 hours to reach the necessary hardening temperature, the time taken varying with the weight of metal to be heated. The hardening temperature varies somewhat according to the class of steel being used, but may be said to be between 2000 deg. Fah. and 2100 deg. Fah. The exact temperature necessary for satisfactorily hardening any particular class of steel is previously determined in the laboratory by exact experiments, and the temperatures obtained in the furnace are checked by means of a Fery radiation pyrometer, also shown in Fig. 2. This pyrometer is itself tested against a standardised Callendar pyrometer, and has so far been found to give extremely reliable results.

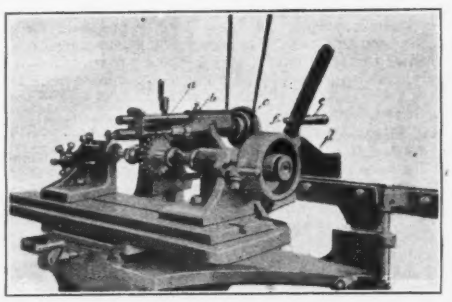


Fig. 4—BACKING OFF CUTTER TEETH

The cutters, when sufficiently heated, are quickly removed from the charcoal in which they have been packed, and are at once placed upon the hardening table, shown in Fig. 3. This table is of a type frequently used in workshops for heating tools by gas, but when used for hardening cutters, air only is supplied through the two nozzles. These can be moved as required about vertical pivots, so as to cause the air blast to impinge upon the periphery of the cutters at any required points, and simultaneously upon the vanes of the spindle upon which the cutter is placed, causing the whole arrangement to rotate, and thus equalising the cooling and hardening effect. The air delivered upon the cutter is drawn from an old culvert, which

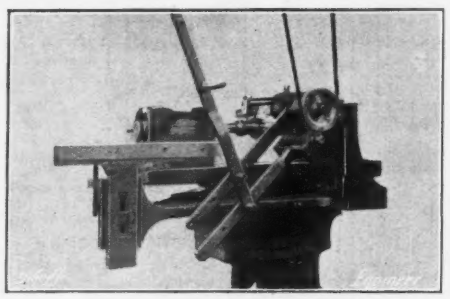


Fig. 5—BACKING OFF CUTTER TEETH

passes under the floor of the workshop, and through which a stream of water continually flows; hence at all times of the year a supply of cold damp air of maximum cooling effect is available. The temperatures used in hardening are such that the edges of the cutters are almost fused, and although different makes of steel have been found to vary somewhat in this respect, the general statement remains true of all of them. At the same time, it is found that this fusing effect for a given heat is considerably minimised by the method of heating in closed boxes as compared with the ordinary method of heating tools, either in a muffle or in a direct gas flame, and even the scaling, which, with the latter systems, is frequently very marked, is, with the method now described, so slight that the cutters can be wholly freed from scale by placing momentarily under a revolving scratch brush.

All difficulties as regards the expansion of the hole through the cutters in hardening are met initially, leaving the bore slightly smaller than is ultimately required—on the average about 0·01in. less than the finished diameter; the expansion is usually about 0·003in. to 0·005in., the average diameter of the mandril being 1in. After hardening, the milling cutters are first chucked truly with the outside diameter in a self-centering chuck, and the internal bore is ground up truly to the finished diameter. After this the hardened cutters are chucked upon mandrils, and the teeth are finished upon the special machines to be described.

(3) *Forming cutter teeth*.—Accuracy of form of the cutters is secured, both when being cut in the first place and also subsequently reformed, by turning the blanks and milling out the teeth in the ordinary manner, and then backing them off in the machine shown in Figs. 4 to 7. In this machine the cutter to be formed is carried on a dividing head, so that one tooth at a time can be presented to the small milling cutter *a*, Fig. 4. This is mounted upon the cutter spindle *b*, driven by a pulley *c*, from which cat-gut cord runs through an overhead gear, allowing the spindle to be moved within the necessary limits. The small cutter spindle frame forms part of a system of adjustable pantograph links, so that its movement is an exact reproduction in miniature of the movement of the tracing pin upon the former *d* fixed in front of the machine. The operator, by means of the handle *e*, moves the pin *f* lightly along the former, and consequently also moves the cutter over the tops of the teeth to a similar but smaller shape. The small cutter is enlarged in diameter towards one end, so that it cuts away the back of each tooth upon the cutter to the necessary extent. Commonly a conical backing-off cutter is used, the angle of the cone being 20 deg., and the setting being such as to give an angle of relief of 10 deg.—that is, the axis of the cone is at right angles to

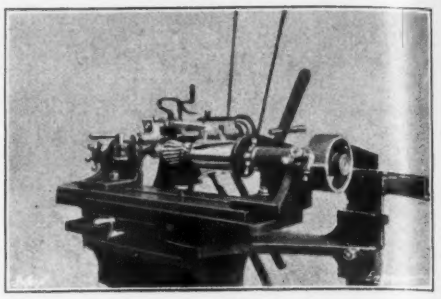


Fig. 6—BACKING OFF CUTTER TEETH

the radial face of the tooth being backed off. It will be seen that this characteristic enables the machine to produce teeth of any form upon a cutter backed off in every direction from the cutting edge, so that a clean cut can be taken with the sides as well as with the tops of the teeth.

In the case of those milling cutters in which grinding back the faces of the teeth so backed off might cause serious inaccuracy, owing to its throwing back the radial cutting edges of the teeth, the cutters are built up of annular sections which are either clutched together or clamped together upon plain faces, from which, after a particular grinding or series of grinding operations, the same amount is ground off as that by which the radial cutting edge has receded. Where the edges of the teeth are parallel or nearly parallel to the axis of the cutter, the profile is of course not appreciably affected by grinding back the faces of the teeth. A further means of avoiding such errors is also to be found in grinding the tops of the teeth in the manner subsequently described.

As it is found advantageous, in order to obtain a fine finish, to use helical teeth upon milling cutters, a fitting consisting of a sleeve with spiral slot—see Figs. 6 and 7—can be mounted on the same spindle as the milling cutter. A pin on a hinged arm centred above the backing-off cutter spindle is arranged to slide in the slot in this sleeve so that, as the frame carrying the copy and the cutter spindle is moved backwards and forwards along the axis of the cutter being backed off, the helical teeth are maintained in correct relation to the backing-off cutter; while at the same time they are backed off to the correct profile. Theoretically, of course, in such cases the axis of the cutter being operated upon

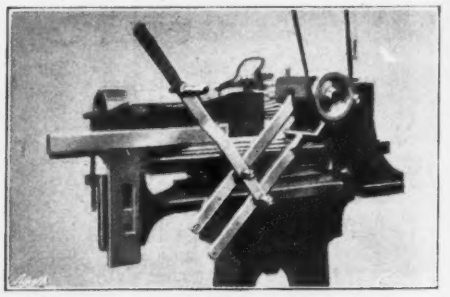


Fig. 7—BACKING OFF CUTTER TEETH

could be inclined to the axis of the backing-off cutter spindle at an angle equal to that of the spiral of the cutter being produced, but in actual practice it is found that this adjustment is very seldom necessary, as the cone angle of the backing off cutter, and also the amount of material which can be removed from the cutting edge of the cutter being produced, are both, comparatively speaking, small.

This machine has thus been found not only capable of backing off satisfactorily cutters of a shape which could not be backed off along the whole length of their profile in an ordinary relieving lathe in one operation, but it has been found possible to do the backing off in, approximately, one-third of the time required on a relieving lathe, whilst at the same time a less expensive class of labour may be employed, and the finish of the teeth is found to be better.

(4) *Grinding cutters*.—Figs. 8 and 9 show the machine used for sharpening the cutting edges of the hardened milling cutters and subsequently regrinding their faces or edges as required from time to time.

This machine has a grinding wheel mounted upon a spindle suspended on a swinging frame and follows the work by the use of a former, the profile of which is of the same magnitude as the one to be ground. In an ordinary way this former would not have the exact outline of the shape desired on the finished cutter, corrections having to be applied for the diameters of the tracing roller and also of the grinding wheel, the latter item being, of course, itself variable. This difficulty is overcome by using grinding wheels of special fast cutting artificial stone which will perform a considerable amount of useful work before being appreciably reduced in diameter, and by making the diameter of the tracing roller equal to the diameter of the grinding wheel; there is in addition, of course, an adjustment for raising or lowering the former.

The milling cutter being ground is, as before, mounted upon a

* The Institution of Mechanical Engineers.

dividing head in the case of straight cutters, or upon a dividing head provided with helical sleeve in addition in the case of helical teeth cutters, and all the teeth are first ground along the tops to profile and afterwards in the usual manner down their faces, the grinding wheel being, of course, set over to the angle of the spiral. The cutter thus finished has edges both of the maximum keenness and also of the maximum endurance due to correctly hardened high-speed steel, as only the thin skin partially oxidised in heating before hardening is removed.

Hitherto the apparatus employed upon sharpening profile cutters for milling machines in repetition work, such as is produced in small arms factories and elsewhere, has required the handling and attention of men with considerable training and skill, liable to error, and, consequently, well paid to avoid it. The provision of simple machines such as those described now enables an unskilled

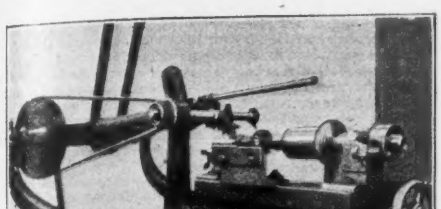


Fig. 8—GRINDING CUTTERS

man to re-grind correctly all cutters brought to him with considerable rapidity and the minimum possibility of error. By standardisation of the pitches of the teeth and their angles, and by the provision of suitable templates for each of the cutters commonly required, the use of these machines has been found to result in distinct economy, both in the upkeep of cutters and also in the quality of the work turned out.

Considerable advantages result from being able to reform accurately the contour of the teeth in addition to grinding the face. In ordinary use the teeth of milling cutters are damaged not only on the face, but to an even greater extent on the top, and it has frequently been found that removing, say, 0·002in. from the top has as beneficial an effect as removing 0·006in. from the face, and with this additional advantage that, when a tooth has been ground to its fullest extent from the face, it can be further sharpened on the top whilst still retaining its correct figure, until the tooth is too short through not allowing the necessary clearance; and this consideration will in many cases lengthen the life of a cutter by 10 per cent.

The life of some milling cutters prepared by the methods indi-

Fig. 9—GRINDING CUTTERS

cated above has been extraordinary; for example, a cutter working in a self-acting cross milling machine and operating upon the bodies of the service rifle at an average cutting speed of 69ft. per minute, with a feed of 1½in. per minute and a depth of 0·08in., and taking a cut of an average width of 1¼in. and ⅝in. long, has produced, at the time of writing, 39,170 bodies and is still good for about half as many more. This particular cutter has been reground across its face twenty-five times. The composition of the steel upon which it operates is 0·5 to 0·6 carbon with an ultimate tensile strength of not less than 35 tons per square inch.

THE INSTITUTION OF CIVIL ENGINEERS.

KEYHAM DOCKYARD EXTENSION.

At the ordinary meeting on Tuesday, the 17th December, Sir William Matthews, K.C.M.G., president, in the chair, the papers read were "Keyham Dockyard Extension," by Sir Whately Eliot, M. Inst. C.E., and "Keyham Dockyard Extension: Temporary Works, and Plant and Appliances used during Construction," by Geo. H. Scott, M. Inst. C.E. The following are abstracts of these papers:—

The Keyham Dockyard extension is situated north of the Keyham yard, and occupies an area of 118 acres, of which 77 acres were mud foreshore. The works consist of three graving docks, two of them opening into a tidal basin of 10 acres at the south end, and all of them opening into a closed basin of 35½ acres at the north end. Also of a lock giving access to the closed basin. A retaining wall has been built along the east boundary of the new works which adjoin the higher ground of the naval barracks. The new works necessitated the diversion of sewers and the construction of new outfalls.

The whole area of the works was enclosed on the water side by a cofferdam 5576ft. in length, which entirely excluded the tidal water. Portions of the works situated landward of high water line were commenced while the cofferdam was being constructed.

The tidal basin is 10 acres in extent. The walls are everywhere founded on rock, the depth varying from 57ft. to 80ft. below the coping, and the bottom of the basin being 55ft. below coping. The walls are constructed of concrete, the upper part faced with granite. The face of the wall is formed to a batter of 1 in 8 in the upper part, in the lower part to a batter of 1 in 4, the two parts being joined by a curve of 135ft. radius. On the west side is the entrance, 120ft. wide. Timber fendering is fixed to the upper part of the walls.

The closed basin is 35½ acres in extent, including the pier, and the formation of the walls is practically the same as for the tidal basin. The height of the walls from foundation to coping varied from 57ft. 6in. to 108ft. The bottom of the basin is 55ft. 6in. below coping, and 32ft. 6in. below low water of spring tides. From the centre of the north wall a pier extends into the basin. This pier is 500ft. long and 75ft. wide. On the west side of the basin an entrance is constructed 95ft. wide, and with a depth on the sill of 32ft. at low water of spring tides. The entrance is closed by a sliding caisson, and also by a floating caisson.

When the mud had been removed from the site of the docks, and the rock cut out to the form and depth required, concrete was deposited, the average depth under the centre part of the floor being 14ft., and under the side parts 12ft. 6in. The concrete was deposited in sections, and to the full depth, to avoid horizontal joints. The floor stones of granite were bonded into the concrete and bedded in cement mortar. After the concrete of the floor was completed, the side walls were commenced. Up to the level of the first broad altar, the beds of the granite face stones radiate, the concrete at the back having been first deposited and shaped to receive the face stones. In the upper part of the walls the face stones were set on a level bed, and afterwards backed with concrete. The walls of the docks and lock above the top broad altar are faced with concrete blocks having a granolithic face. Each dock and lock is provided with steps and slides. Dock No. 4 is 650ft. long, dock No. 5 is 745ft., dock No. 6 is 741ft., and the lock is 730ft. long. All the entrances are 95ft. wide, and fitted with sliding caissons. In docks 5 and 6 a floating caisson is fitted into a groove dividing each dock into two separate docks, if required. The width of all the docks on the floor is 70ft., and at the coping 121ft. The lock is constructed so that it can be used at any time as a graving dock. The depth of water at low water of springs on the sills of docks Nos. 4 and 5 is 20ft. 6in., of dock No. 6 and the lock 32ft. The floor of each of the docks is 4ft. 6in. below the floor of the entrance, the two floors being connected by five steps of granite set to a curve on plan with radial joints.

The outer wall forms the west and north boundary of the new works, and extends from the south end of the lock to a point near to and north of the Naval Barracks. The total length of the wall is 4730ft.; it is founded throughout on rock. For half the length the depth of mud varied between 30ft. and 60ft., and for the remaining half it varied between 60ft. and 100ft. In order to reach the rock through such a depth of mud a special form of concrete column was used. These columns were built in rings 2ft. 6in. thick, the rings being in sections, and jointed with cement mortar. Three wells were formed in each column, through which excavating grabs worked and brought up mud from the bottom of the column. The base of each column was provided with a cutting ring of concrete 5ft. in depth, and formed in one piece, strengthened with iron bands embedded in the concrete. The ring was made *in situ*, and when it was ready to be sunk, built up rings were added, and the mud was lifted from the wells by grabs, weights being placed on the top of the column to force it through the mud. The columns were sunk until the rock was reached, which was then levelled by hand, and the wells were filled with concrete. When the depth of mud did not exceed 60ft., a single row of columns was sunk, and a timbered trench was excavated at the back, in which the back part of the foundation was constructed of concrete, which was packed around and between the columns, spaced 10ft. apart. When the depth of mud exceeded 60ft., it was necessary to sink a double row of columns, 3ft. apart transversely. The spaces between the columns were then cleared of mud and filled with concrete. The sinking of the columns was carried out very successfully, and a solid foundation was obtained on which to build the upper wall, which is faced with concrete up to 26ft. 6in. below the coping, and above that level with granite, to which is attached a fendering of timber.

For filling the docks with water, two culverts, 8ft. high and 6ft. wide, are provided at each end, and fitted with penstocks. For emptying the docks two main culverts, 7ft. in diameter, are provided, one at each end, and connected by branch culverts to the interior of the docks. The water is conducted by these culverts to the main pumping engines. Subways are constructed at the back of the basin walls and outer wall, in which are placed two cast iron pipes, 9in. in diameter, for the supply of fresh and salt water, and also a cast iron pipe, 15in. in diameter, for conveying compressed air from the compressors in the engine-house, for working the caissons, penstocks, and other machinery.

The sliding caissons at the entrances to the docks, lock, and closed basin are box-shaped and constructed of mild steel; their buoyancy is adjusted by iron ballast and water. They are hauled into and out of the cambers by chains worked by compressed air engines. The floating caissons are constructed of mild steel, and are raised or lowered by adjusting the water ballast in the tanks.

The main pumps for emptying the docks are in duplicate, and of the vertical-spindle centrifugal type revolving horizontally; the spindle is driven direct by a horizonal compound steam engine. The drainage pumps are in duplicate, each set consisting of three single-acting lift pumps worked by a set of vertical compound engines. The pumps all working together are capable of lifting 6,600,000 gallons per hour. Two duplex pumping engines are also provided for lifting sea water from the tidal basin to a large tank fixed on the roof of the engine-house, from which a supply is carried to various parts of the dockyard.

By dredging, a depth of 32ft. of water at low water of spring tides has been obtained along the outer wall, except for the portion facing Weston Mill Lake, where the depth varies from 32ft. at the west end to 15ft. at the east end, where the new landing stage for the naval barracks has been erected. The works were commenced in January, 1896, and completed at the end of 1906.

The temporary works and appliances which form the subject of the second paper are dealt with mainly under the following heads:—

Cofferdams.—The works are situated at Devonport, on the estuary of the river Tamar, called the Hamoaze, and two-thirds of the site required for the extension of the dockyard had to be reclaimed from the estuary. This was effected by a timber cofferdam nearly 8000ft. in length. Half of this length consisted of a double row of whole timber sheet piling, driven about 40ft. into the mud, and finishing at a level of 7ft. 6in. above H.W.O.S.T., the remainder being composed of a single row of whole timber sheet piling. At the most southerly end the dam consisted of a temporary concrete wall, about 300ft. long and 30ft. high. The cofferdams and the means employed in their construction are described in some detail.

Stagings, &c., for excavation.—As there was a great depth of soft mud over the reclaimed area it was necessary to construct timber stagings upon which to work with steam cranes and locomotives and wagons for the trench and other excavation, and afterwards for depositing the concrete for the basin and dock walls. The total length of these stagings was about 6000ft. They consisted generally of three, and in some cases four, whole-timber piles driven to the rock when possible. These stagings are fully described.

Unloading jetties.—Two unloading jetties for receiving materials required for the work were constructed, each 300ft. long, being placed 39ft. apart, so as to provide a berth between them for the large craft bringing shingle and sand for concrete. These jetties are briefly described.

Concreting plant.—Taylor mixers, of one cubic yard capacity, were used, nine of them, with the necessary stagings, being provided at various parts of the work.

Building of docks.—There were three graving docks, respectively 660ft., 741ft., and 745ft. long, and a lock entrance 730ft. long, all with entrances 95ft. in clear width. They were built of concrete, faced with granite, about one-half of which was procured in Cornwall and the remainder in Norway. Granolithic blocks were used to a considerable extent also for facing the upper portion of the dock walls. The stagings for building the docks, and the appliances used, are fully described.

Temporary repairing shops.—A very complete installation of repairing shops was provided, as it was necessary to carry out larger repairs on the site than are usual on public works. The various shops are briefly described.

CATALOGUES.

JOHNSON AND PHILLIPS, Limited, Charlton, Kent.—List No. 41, which describes and illustrates vertical carbon flame arc lamps. This is a new lamp which the firm have recently put upon the market which is said to have a very high efficiency and to give an intense light of a pale yellow tint.

THE STOLZENBERG PATENT FILE COMPANY, 50-53, Bishopsgate-street Without, E.C.—We have received a quantity of literature from this firm describing safety deed and cash boxes, catalogue covers, roll top desks, flat desks, stationery cabinets, a new patented steel binder, and other office furniture.

HORACE P. MARSHALL AND CO., 6 and 7, Cross Fountaine-street, Leeds.—A circular to hand from this firm has reference to Morton's patented rivet furnace. We understand that this is a distinct departure from pre-existing designs, and it is claimed that it gives very satisfactory results.

S. H. HEYWOOD AND CO., Reddish, near Stockport.—A circular to hand from this firm deals with electric pulley blocks. We are informed that these blocks can be fixed in any position where a lift is required, and that they take up about the same amount of room as an ordinary hand operated block.

JAMES POLLOCK, SONS AND CO., Limited, 3, Lloyd's-avenue, London, E.C.—This is an interesting pamphlet on gold dredging. It deals with alluvial gold, prospecting, sampling, gold dredges, cost of running bucket and ladder dredges, conditions of the gold, quality of gold, returns to be expected, and other points of interest concerning the subject.

THE DAIMLER MOTOR COMPANY, 219-229, Shaftesbury-avenue, W.C.—We have received a little booklet from this firm, entitled "An Indian Trip on a Daimler Car." It describes an interesting run, full of adventure, from Umballa to Peshawar. We have also received a much larger book from this firm which contains a large number of testimonials in *facsimile*.

THE KEMPSMITH MANUFACTURING COMPANY (London agents, Selig, Sonnenthal and Co., 85, Queen Victoria-street, E.C.)—This is a catalogue dealing with milling machines and attachments. A number of plain and universal milling machines is illustrated, each of which is accompanied with a full description. The various attachments are also equally well described.

THE BRITISH FUEL ECONOMISER AND SMOKE PREVENTER, 9, Bedford-row, London, W.C.—A little booklet from this firm is entitled "The Bunsen Bridge, and How it Affects Coal Bills and Smoke Nuisance." It contains drawings of the device, illustrations of plants fitted with this form of smoke preventer, and full particulars concerning it. We have also received a list of testimonials.

THE INDENTED STEEL BAR COMPANY, Queen Anne's-chambers, Westminster, S.W.—An extensive catalogue, which has been forwarded to us by this firm, deals with the firm's indented steel bars for use in reinforced concrete construction. It also gives numerous illustrations of work done in this country. In addition, there is some reading matter relating to the theory of work of this class, which adds to the value of the catalogue very materially.

THE SMOOTH-ON MANUFACTURING COMPANY, 8, White-street Moorfields, E.C.—We have received an instruction book from this firm which gives instructions for using the various smooth-on cements manufactured by the firm. These cements are for repairing blemishes, blow-holes, or defects in castings, for repairing leaks or breaks in castings, and for making connections in steam and hydraulic work, &c. &c. The book is well illustrated.

EDWARD WOOD AND CO., Limited, 88, Cannon-street, E.C.—A copy of this firm's latest publication which has been forwarded to us is entitled "Steel Structures." It contains illustrations showing the firm's standard designs of roof trusses, stanchions and girders, which are particularly adapted for workshop construction. There is also a number of fine illustrations showing some buildings at home and abroad for which Messrs. Edward Wood and Co. were the contractors.

SIEMENS BROTHERS, Queen Anne's-chambers, Broadway, Westminster, S.W.—This is a new and interesting catalogue dealing with thermo-electrical pyrometers and temperature indicators and recorders. The instruments described and illustrated in this catalogue represent the latest practice in connection with apparatus of this class. We are informed that they are suitable for all processes in which the accurate determination of temperature is a necessary factor between the limits of about – 190 deg. Cent. and + 1600 deg. Cent.

WILLANS AND ROBINSON, Limited, Rugby, England.—This is an advance copy of a new catalogue dealing with surface condensers. It contains many excellent illustrations, showing surface condensers of various sizes. There are also some interesting illustrations showing Edwards' air pumps, as built by Messrs. Willans and Robinson. These illustrations show the process of dismantling these pumps. Whilst the catalogue deals more particularly with ordinary surface condensers, it also has reference to "Vacuum augmentors," and "Contraflo" condensers. We have also received a list of surface condensing plants supplied and on order.

THE GENERAL ELECTRIC COMPANY, 71, Queen Victoria-street, London, E.C.—We have received a copy of this firm's latest medical catalogue. It deals with electro-medical apparatus of all kinds, including induction coils, magneto machines, and various electrodes for use with these machines. It also gives illustrations and particulars of apparatus for producing Röntgen rays, cautery apparatus, medical electric lamps, the "Greeko" electric dental engine, and batteries of various descriptions. Another catalogue to hand from this firm deals with Sherardised Conduct, which is a conduit which the firm claim to be the best for all wiring purposes. We have also received an elaborate showcard, which illustrates and gives particulars of Osram lamps with tungsten metal filaments.

THE ELECTRIC AND ORDNANCE ACCESSORIES COMPANY, Limited, Cheston-road, Ashton, Birmingham.—This is a well compiled catalogue recently issued by this firm, dealing with the "Victor" arc lamps. We understand that three distinct types of lamps have been standardised by the firm, the "Standard," "Minature," and "Flame" lamps, each possessing distinct and novel features. We also understand that several other patterns are at present under construction, including twin and triple carbon lamps, also lamps for use on alternating current circuits. One of the main features about these lamps is their extreme simplicity. The catalogue contains a full description of each type of lamp, and prices and other particulars are also included. At the end of the catalogue arc lamp accessories are dealt with.

GILBERT GILKES AND CO., Limited, Civil Engineers, Kendal, England.—This is a newly issued water turbine catalogue. It has reference to water turbines of many different types, and there are numerous illustrations. The types dealt with include double vortex turbines, single discharge turbines with horizontal shafts. The Pelton wheel is shown in many sizes, and it is also shown driving machinery of various kinds. One striking illustration shows a Pelton wheel 21ft. in diameter. It is designed to develop 200 horse-power on a 98ft. fall at 36 revolutions per minute. This particular Pelton wheel is coupled to the shaft of tin-plate rolls; the speed is controlled by means of a hydraulic governor which works on an equilibrium valve. Among other turbines described and illustrated are the Girard turbine, both with horizontal and vertical shafts, the Kendal turbine, the Trent turbine, and a number of others. Prices and particulars are given for numerous sizes, and at the end of the catalogue turbine accessories are dealt with.

AMERICAN ENGINEERING NEWS.

The steam curing of concrete.—One of the difficulties encountered in the concrete building-block system of building construction, now in extensive use in the United States, is the long time required for the concrete properly to set, before it can be used in the work. The usual process is to stack the blocks in a shady sheltered place for some weeks, sprinkling them with water at short intervals. Some manufacturers have experimented with rapid curing by placing the blocks in a steam bath or steam chamber as soon as they are moulded, while in some cases carbon-dioxide gas is added to the steam. There is a great diversity of opinion as to the value of this treatment, and some extended tests have therefore been made at the Lewis Institute. The tests were made on circular blocks or columns, 8in. diameter and 16in. high, the concrete being a mixture of 1 cement, 3 sand, and 4½ gravel, rammed into sheet iron moulds with a pneumatic rammer. For convenience of handling, the blocks were kept in the moulding room for twenty-four hours, being sprinkled at intervals. The steam curing was done in a cylindrical chamber, and after this the blocks were either stacked in the open air, placed in water, or placed in a moist room and kept damp by sprinkling. They were then crushed in a testing machine, showing a strength of 840 lb. per square inch with only three hours' steaming to 820 lb. and 1000 lb. with seventy-two hours. This was for blocks placed in the open air. Those given the damp treatment after curing showed as high as 1170 to 1522 lb. per square inch. The general conclusion was that concrete steamed for over twenty-four hours shows an ultimate crushing strength higher than that of concrete cured in the usual way.

Electrification of the New York, Newhaven and Hartford Railway.—This is the second railway entering New York City which has now complied with the law prohibiting the use of steam locomotives within the city, and for its own convenience it has gone beyond the requirements of the law in applying the electrification over the entire distance covered by its suburban service—a distance of 35 miles. The high-tension single-phase system is used, but the locomotives can also operate on the direct-current lines of the New York Central Railway, by which the trains reach the New York terminus. There are four main lines of rail, with numerous sidings and additional tracks, and these are spanned by steel truss bridges—like signal bridges—at intervals of 300ft. These are 23½ft. clear above the rails. The bridges support the catenary cables, two to each line of rails, and triangular stirrups on these carry the trolley wire. The locomotives are mounted on two four-wheeled bogies, with a 250 horse-power motor on each axle. The wheels are 5ft. 3in. diameter and the locomotive weighs 90 tons. Each engine is designed to handle a 200-ton train, that being the weight of most trains in the electrified zone. It can haul such a train 65 to 70 miles an hour, and a 250-ton train at 60 miles. For the heavier trains, ranging as high as 630 tons, two or three engines will be coupled together, operating as one unit. A 25-cycle 11,000-volt alternating current is used, generated by Parsons-Westinghouse steam turbines of 4500 horse-power and generators of 3000 kilowatts. No sub-stations are used, but the 11,000-volt current is taken from the trolley wire by bow contacts and to step-down trans-formers on the engines.

A steel works gantry crane.—The Illinois Steel Company has installed at its South Chicago works a 15-ton gantry crane for handling material in the yard. The two rails are laid at the ground level, and are 56ft. apart. On each of them is a steel tower, 25ft. long, with four grooved wheels in tandem, two at each end. Between the towers are two latticed girders, on the top booms of which are laid the rails for the crane traveller. Upon this again traverses the hoisting trolley. The girders are 101ft. long, having cantilever extensions beyond the towers of 30ft. at one end and 15ft. at the other. These extensions overhang railway sidings, so as to handle material to or from the wagons, and the full width between the towers is available for storage. The towers and girders are all built up of plates and angles. The four wheels at each end are connected in pairs by equalising beams to compensate for any irregularities in the rails. Two of the wheels at each end are connected by pinions and spur gears with the driving mechanism. With the full load of 15 tons, the speed of hoisting is 30ft. per minute. The trolley can travel along the bridge at 150ft. per minute, and the crane can travel along the rails at 250ft. per minute. In all the machinery the pinions are cut from open-hearth steel forgings, while the spur wheels are cut from solid blanks. The hoisting machinery has an electric motor brake and a mechanical load brake, both running in an oil bath. The travelling motor is placed at the middle of one of the girders, with its shaft extending to each tower, where it drives a vertical shaft by bevel gearing. The operator's cabin is hung below one of the girders, so that the man has a good view of the yard and of the work.

LAUNCHES AND TRIAL TRIPS.

REINA VICTORIA, steel screw steamer; built by Messrs. Swan, Hunter and Wigham Richardson, Limited; to the order of the Sociedad Navegacion e Industria, of Barcelona; dimensions 250ft. by 32ft. beam; engines, triple-expansion; constructed by the builders; trial trip, November 26th.

QUEEN ALEXANDRA, steel towing launch; built by Edward Hayes; dimensions, 51ft. by 11ft. by 4ft.; engines, compound, 8in., 16in. by 10in. stroke, pressure 120 lb.; constructed by the builders; trial trip, November 26th.

GANELON, steel screw steamer; built by Messrs. Swan, Hunter and Wigham Richardson; to the order of Roland-Linie Aktien-Gesellschaft, Bremen; dimensions, 425ft. by 35ft. by 32ft.; to carry 8000 tons; engines, triple-expansion; constructed by the Wallsend Slipway and Engineering Company; trial trip, November 30th.

REDWOOD, steel screw steamer; built by the Blyth Shipbuilding Company; to the order of the Tyneside Line, Limited; dimensions, 244ft. by 33ft. 6in. beam; engines, triple-expansion; constructed by the North-Eastern Marine Engineering Company; launch, December 1st.

CEYLON, steel twin screw steamer; built by Messrs. Swan, Hunter and Wigham Richardson; to the order of La Compagnie Chargeurs Réunis, of Paris; dimensions, 500ft. by 55ft. 8in. by 33ft. 11in.; to carry 9000 tons; engines, triple-expansion; constructed by the Wallsend Slipway and Engineering Company; trial trip, December 3rd.

STEEL screw cargo vessel; built by Messrs. Swan, Hunter and Wigham Richardson, Limited; to the order of the Compagnie Generale Transatlantique, of Paris; dimensions, 325ft. by 43ft. 6in.; to carry 4200 tons; engines, triple-expansion; constructed by the builders; launch, December 5th.

MUSKETEER, steel screw steamer; built by the Tyne Iron Shipbuilding Company; to the order of Messrs. Fisher, Renwick and Co.; dimensions, 230ft. by 33ft. by 21ft.; engines, triple-expansion, 17in., 28in., 46in. by 33in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; launch, December 5th.

WESTWOOD, steel screw cantilever steamer; built by Sir Raylton Dixon and Co.; to the order of Messrs. Furness, Withy and Co.; dimensions, 286ft. 4in. by 40ft. 5in. by 22ft. 11in.; to carry 3300 tons; engines, triple-expansion, 20½in., 33in., 54in. by 36in. stroke, pressure 180 lb.; constructed by Messrs. Richardsons, Westgarth; launch, December 5th.

FRANCES, steel screw steamer; built by the Laxevaags Engineering and Shipbuilding Company, Bergen, Norway; to the order of Messrs. D. Ellerhusen and Co., of Bergen; dimensions, 239ft. by 36ft. by 16ft. 9in.; engines, triple-expansion, 16½in., 27in., 44in. by 30in., pressure 180 lb.; constructed by the builders; launch, December 7th.

HORLSEYWOOD, steel screw steamer; built by Messrs. Ropner and Sons; to the order of the Constantine and Pickering Steamship Company; to carry 4650 tons; engines, triple-expansion; constructed by Messrs. Blair and Co.; trial trip, December 7th.

CRISPIN, steel screw steamer; built by Sir Raylton Dixon and Co.; to the order of the Booth Steamship Company; dimensions, 366ft. 4in. by 49ft. 3in. by 26ft. 6in.; to carry 5900 tons; engines, triple-expansion, 25in., 41in., 65in. by 48in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; trial trip, December 9th.

CUBATAO, steel screw steamer; built by Messrs. Craig, Taylor and Co.; to the order of Messrs Lloyd Brazileiro, of Rio de Janeiro; dimensions, 286ft. by 44ft. 9in. by 17ft. 6in.; engines, triple-expansion, 14in., 22in., 37in. by 24in. stroke, pressure 185 lb.; constructed by Messrs. Blair and Co.; trial trip, December 10th.

BUFFALO, steel screw steamer; built by Earle's Shipbuilding and Engineering Company; to the order of Messrs. Thomas Wilson, Sons and Co.; dimensions, 377ft. by 49ft. by 30ft.; to carry 7000 tons; engines, quadruple-expansion, 22in., 45in., 45in., 66in., by 51in. stroke, pressure 215 lb.; trial trip, December 17th.

BORBOREMA, twin screw steamer; built by Messrs. Craig, Taylor and Co.; to the order of the Lloyd Brazileiro; dimensions, 286ft. by 44ft. 9in. by 17ft. 6in.; engines, triple-expansion, 14in., 22in., 37in. by 24in. stroke, pressure 185 lb.; constructed by Messrs. Blair and Co.; launch, December 17th.

TUSCANY, steel screw steamer; built by Irvine's Shipbuilding and Dry Dock Company; to the order of The Furness Line; dimensions, 336ft. by 47ft. by 24ft. 10in.; engines, triple-expansion, 24in., 38in., 64in. by 42in. stroke, pressure 160 lb.; constructed by Messrs. Richardson Westgarth; launch, December 19th.

DACRE CASTLE, steel screw cargo steamer; built by Messrs. R. Craggs and Sons, Limited; to the order of the Lancashire Shipping Company, Liverpool; dimensions, 392ft. by 53ft. 6in. by 28ft.; engines, triple-expansion, 26½in., 44in., 72in. by 48in. stroke, pressure 180 lb.; constructed by Messrs. Blair and Co.; launch, December 19th.

ROMANBY, steel screw steamer; built by Messrs. Ropner and Sons; to the order of Messrs. R. Ropner and Co., West Hartlepool; dimensions, 365ft. by 50ft. by 23ft.; engines, triple-expansion, pressure 180 lb.; constructed by Messrs. Blair and Co.; launch, December 19th.

COLTMAN, steam trawler; built by Earle's Shipbuilding and Engineering Company; to the order of the City Steam Trawling Company, Limited, Hull; trial trip, December 20th.

WESTWOOD, steel screw steamer; built by Sir Raylton Dixon and Co.; to the order of Messrs. Furness, Withy and Co., West Hartlepool; dimensions, 286ft. 4in. by 40ft. 5in. by 29ft. 11in.; to carry 3300 tons; engines, triple-expansion, 20½in., 33in., 54in. by 36in. stroke, pressure 180 lb.; constructed by Messrs. Richardsons, Westgarth; trial trip, December 21st.

AUSTRALIAN NOTES.

ALTHOUGH the outlook is not very promising on account of the prolonged drought in New South Wales, the effects of its ravages are not yet felt, and the state of the railway and tramway traffic for the quarter ending September last shows a very favourable increase. Compared with the corresponding quarter of last year, the gross earnings show an increase of £153,225, and the expenditure an increase of £72,628, the net result being an improvement of £80,598. Nearly all classes of traffic have contributed to the improvement, viz.:—Passengers and parcels, £23,000; general merchandise, £46,898; wool, £41,335; live stock, £23,804; coal and coke, £15,028; other minerals, £7626; 1,586,912 additional passengers were carried; and the train miles were increased by 445,385.

STATE OF THE TRAFFIC.

Railways.

	Quarter ended 30th September, 1907.	Quarter ended 30th September, 1906.
Miles open	3468½	3320½
Revenue	£1,207,845	£1,054,619
Expenditure	£609,116	£522,488
Train miles run	3 406,058	2,960,673
Earnings per train mile	7s. 1d.	7s. 1½d.
Expenditure per train mile	4s. 1d.	4s 2½d.
Expenditure to earnings	51·55 per cent.	59·02 per cent.
Passengers carried	11,190,407	9,603,425
Goods traffic	634 222 tons	529,557
Coal and coke	1,718,940 tons	1,4 8 008 tons
Other minerals	151,648 tons	93,958 tons
Live stock	86,437 tons	82,172 tons

Tramways.

Miles open	130	126½
Revenue	£228,490	£205,248
Expenditure	£187,954	£167 988
Tram miles run	4 236,413	4,077,524
Earnings per tram mile	1s. 1d.	1s.
Expenditure per tram mile	10¾d.	9¾d.
Expenditure to earnings	82·26 per cent.	81·85 per cent.
Passengers carried	39,117,779	35,141,791

The new mail contract that is now about to be concluded has been dealt with in a businesslike manner, and has been shorn of all the experimental fads that the Federal Government wanted to enter into over the late fiasco. Negotiations between the Federal Government and the Orient Royal Mail Company for a ten years' contract for the carriage of mails between Australia and England have now been practically completed. The amount of subsidy asked for has not been published, although it is stated that it ranges between £140,000 to £165,000 per annum, according to services rendered.

Great unrest prevails in the Newcastle (N.S.W.) mining centres, and the periodical threat of a strike by the colliers is again put forward. For some time past the coal trade has been exceedingly brisk, and the men think it a good time to make a demand for an advance of 8d. per ton on the hewing rate to take effect from January next. The proprietors have fixed the price of coal at 11s. per ton, but the miners consider that owing to the demand the price should be raised to 12s., when, according to the sliding scale, the hewing rate would be advanced by 8d. This the proprietors refuse to do, as owing to the competition on the West Coast of South America from Newcastle-upon-Tyne and American supplies they would be driven out of the market.

Another grievance which has aroused a good deal of discussion is the payment for screened small coal. The miners' representatives claim that the men should be paid 1s. per ton for this coal instead of one-eighth of a penny per ton, as is now paid.

At a conference held recently at Newcastle to discuss these matters the men's demands were refused and a crisis is now impending.

November 5th, 1907.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, December 13th.

NOTWITHSTANDING the general depression in the steel industry, a great deal of heavy construction work involving chiefly structural material is now in sight in this city and vicinity. The estimated requirements for this city alone are 25,000 tons of shapes, the contract for which will probably be placed within thirty days. Bids were received on Monday for 15,000 tons of material for the New York approach to the Manhattan Bridge. About 10,000 tons will be wanted for a hotel of twenty-one storeys to be built on Fifth-avenue. An enormous building demand is held in check right here. The known requirements for projected work foot 75,000 tons. Much of this work was projected several months ago. The largest enterprise that will certainly take material is the McAdoo Tunnel Terminal. For this about 15,000 tons will be required. The projected New York Central Terminal will absorb considerably over 20,000 tons. The Post-office building at the Pennsylvania Terminal will absorb some 20,000 tons.

There are many more smaller enterprises, all of which are artificially held in check by disturbed conditions. Similar conditions prevail in many western cities. The inference to be drawn is that when the situation clears up former activity in structural steel will ensue. If this is accompanied by the prosecution of delayed or postponed railroad work, there will be a return in large measure to the phenomenal conditions prevailing before the recent collapse.

The next great source of demand is the car building shops. Some of them have contracts running through the entire year of 1908. Others will complete contracts sooner, and will be ready for new ones. There is an abundance of business for the shops.

Europe is being loaded up with copper at the estimated rate of 25,000 tons per month in excess of needs. Domestic production and imports are averaging about 30,000 tons. This year's exports will reach about 220,000 tons, or 15,000 tons in excess of the exports last year. Europe's requirements will decline from February.

The Chinese Syndicate has given the tin interest something to think about. Prices are under control. The United States Steel Corporation is a seller this week at 30-30 c.

ALMANACS, DIARIES, &c., FOR 1908.

W. WILSON COBBETT, Limited, of 59, Southwark-street, E.C., makers of the Scandinavia M.C.M. and Saturn beltings, have sent us a tastefully designed almanac, nicely coloured, in the centre of which there is a small oval panel containing a pretty view of an old castle situated on the banks of a small stream.—We have received from F. Reddaway and Co., Limited, Pendleton, Manchester, one of their patented detachable blotting pads. It consists of a stout base of millboard, provided with a slide, into which two separate parts fit. One of these parts is a thick blotting pad, and the other contains a diary and a dated tear-off pad for "Engagements." It is intended that the base shall be permanently retained, whilst the removable parts are renewed year by year. Alfred Cooke, Limited, of Leeds, are the makers, and the example before us is adorned with advertisements of F. Reddaway and Co.'s goods, rubber and canvas belting, hose, &c.—The Sun Fire Office, 63, Threadneedle-street, E.C., has published a useful wall almanac for 1908, which has monthly tear-off slips with easily legible figures.—We have also received a handy pocket calendar for 1908 and a blotting pad suitable for office or other use.—A wall almanac for 1908 to hand from Messrs. C. W. Leavitt and Co., St. Paul-building, New York, also has monthly tear-off slips, and it is headed with an excellent picture.—Electromotors, Limited, 35, Queen Victoria-street, have sent us a large wall almanac of a similar type, mounted on stiff cardboard, which bears illustrations of electric motors driving various forms of machinery. A handsome combined blotting pad and calendar has been forwarded to us by Messrs. Gibbons Brothers, Limited, Dibdale Works, Dudley, Worcester.—Messrs. Marples, Leach and Co., of 6, Victoria-avenue, Bishopsgate-street Without, London, E.C., electrical engineers, have forwarded us a 6in. cardboard slide rule. They inform us that they would be pleased to send one of these on to any reader who will drop a postcard to them.—The Gloucester Railway Carriage and Wagon Company, Limited, has forwarded us a copy of the "Gloucester Diary and Directors' Calendar for 1908." This is a well-bound little book, and, among other things, it contains a list of the stations and junctions attended by the company's wagon repairers.—Messrs. Henry Simon and Co. have sent us a useful desk calendar for 1908, with daily tear-off sheets.—A wall calendar for 1908 received from Messrs. Bullivant and Co., 72, Mark-lane, has monthly tear-off sheets, and it is headed with an effective picture.—Similar calendars have also been received from Messrs. George Cradock and Co., Wakefield; Messrs. Dixon, Mann and Co., 7, East India-avenue, E.C.; the London and North-Western Railway, 64, Fleet-street, E.C.; and the Gandy Belt Manufacturing Company, Seacombe, Cheshire; and we have received from the London and North-Western Railway Company an album of coloured views of the most attractive places reached by its system and connections.

INSTITUTE OF MARINE ENGINEERS.—At the Institute of Marine Engineers, on Monday, December 16th, the adjourned discussion took place on the papers by Mr. Robert Elliott, B.Sc., Vice-president, on "Repairs to the Hull of Iron and Steel Vessels," and "Repairs to Machinery." Mr. W. Lawrie, Chairman of Council, presided. In opening the discussion on the first paper, Mr. W. McLaren gave instances of breakdowns and repairs effected. For the preservation of the ballast tank tops, he thought the best practice was the regular use of engine oil. He advocated filling in white metal between the rudder pintle and the gudgeon in repairing the pintle. The Hon. Secretary remarked that if this method were adopted, it would be very necessary for great care to be taken in the application of the metal, and cited a case where neglect in this respect had resulted in the rudder being prevented from moving until the metal was melted out again. Mr. J. H. Redman considered that the use of a bolt and strong back for bringing a plate to its original position would tend to produce a strain in the metal in the vicinity of the hole through which the bolt was passed. Before proceeding to discuss the paper on "Repairs to Machinery," the Hon. Secretary, Mr. Jas. Adamson, read the reply to the previous discussion, which Mr. Elliott had sent on in view of his inability to be present. Mr. Elliott first dealt with the question of lining with sheet metal the ends of steel or cast iron propellers to prevent corrosion, a method which he said was seldom resorted to now, as bronze blades were rapidly coming into general use. He did not think it was a good practice to cut off the tips of cast iron propeller blades when pitted. He agreed that a very good method of removing coupling bolts was by means of a monkey, which, in his experience, took the form of an old piston-rod with the lower end cut off and slung on suitable clamps bolted on the shaft. The corrosion in the front end plate of a boiler was due, in most cases, to the water used in cooling the clinker and ashes. In jacking up of furnaces, especially corrugated furnaces, it was usual to fit a hard wood block, the length of the furnace, along the bottom. Wood packing was fitted between the furnace and the shell, under the block, and an iron mould or block at the top of the ram.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Manufactured Iron Outlook.

On the whole finished iron is very quiet, but perhaps not more so than is usual at this time of year. The difference is that ironmasters do not look forward hopefully to January, as they have been in the habit of doing. On the contrary, they feel at present that iron prices must come down to meet the increasing competition of foreign material. Marked Staffordshire bars, for example, keep at the earlier standard of £9, with £9 12s. 6d. as the price of Earl Dudley's bars, but the view is growing week by week that the basis quotation for marked bars must be early reduced to £8 10s. When this comes about boiler plates, hoops and sheets made by the marked iron houses, known as the "list" Staffordshire houses, will also fall 10s. per ton.

Common Finished Iron.

The unmarked bar trade is weak. Common nut and bolt and hurdle qualities can be bought at £6 15s. Good merchant sorts range up to £7 7s. 6d. North Staffordshire crown bars remain at £7 10s., f.o.b. The trade is devoid of animation. Large sizes of bar iron are being gradually pushed out of the field by steel, which can be bought at a price to tempt consumers.

The Sheet Iron Trade.

It is satisfactory that the block-sheet ironmakers are able to hold their own fairly well against foreign competitors—a position which is all the more difficult now that the great bulk of the sheets manufactured are of steel, not of iron. But there is not much to boast about in considering the trade as a whole. The supercession of steel part-products for puddled iron as a material for sheet manufacture still goes on. This week an iron-making concern at Smethwick, South Staffordshire, has given notice to the puddlers that their services are to be dispensed with, it having been determined to employ steel bars and billets in the mills instead of puddled iron in future.

Pig Iron.

Pig iron sales are few as Christmas approaches, and prices easy. The general range of Northamptonshire quotations this week is not above 51s. to 53s. They are not always strong at this, and yet in other cases a shilling or two more is demanded. Quotations, which are largely nominal, are as follows:—Forge pig iron:—Staffordshire common, 54s. to 55s.; part-mine, 56s. to 58s.; best all-mine, 87s. 6d. to 92s. 6d.; cold blast, 115s.; Northamptonshire, 51s. to 53s.; Derbyshire, 55s. to 56s.; North Staffordshire, 57s. to 58s.

Pig Iron Profits.

It may be taken for granted that the manufacture of pig iron has been a very profitable industry throughout the past year, and no doubt most makers have obtained a very excellent return upon their capital. Indeed, it has been several years since many of them did anything like so well as they have done during 1907. The paying off of accumulated back dividends and the large expenditure that has been undertaken in the improvement and extension of furnace plants is decisive evidence on this point. Those concerns have done best who own their own collieries. The fuel item, in which coke and coal are included, has been a very serious one all through 1907, and furnace owners who have had to buy in the open market have not had the chances of such large profit-making as has attached to the more self-contained iron-making concerns.

British and Foreign Steel Trade.

There is still competition in the market for raw steel. Belgian and French material, for instance, is on offer; and though the nominal quotation for steel sheet bars is £4 17s. 6d., it is stated that that price could be shaded considerably were tempting offers made. There has also been fresh talk of competition from the German Stahlwerksverband, but much of this is described as inaccurate and exaggerated. The experience of large buyers of steel bars in this district does not suggest that the Verband is at all anxious to sell. In former times of competition buyers have been only too glad to let all know of their bargains. It is not very likely that they would be more inclined to secrecy on the present occasion. Yet not many purchases are reported. Even if Germany is not competing severely, however, such competition as exists is quite sufficient to depress British quotations. At Newport Bessemer sheet bars have been brought down to £5 and £5 2s. 6d.; but the Welsh makers are not at all disposed to quote these prices for Midland delivery. The general figure in this district is £5 2s. 6d. to £5 5s. Some small transactions have occurred at the top price, but no weight of business is possible.

International Wrought Iron Tube Understanding.

There is still a good deal of talk on the subject of "international arrangements," and alleged "international arrangements," in various departments of the market. A certain amount of truth there may be in the reports that have been prevalent during the last week or two. The general verdict of the market, however, is that the statements and rumours that have been in vogue partake much of the "much-cry-and-little-wool" order. An indication of this is the report this week that Mr. Farrell, of the United States Steel Corporation, has had to return home with only half the schemes that he originally proposed carried into effect. The "understanding" in the wrought iron tube trade seems about as definite as any of the international arrangements which are being talked about. Since last report it is announced that a conclusion regarding the boiler tube branch has just been signed in Paris. Among the parties to it are said to be the British, Belgian, German, and American manufacturers. Whether gas tubes are included is not stated. It is, however, suggestive that the German Gas and Boiler Tube Syndicate acts as one body, and that the German combination has just been extended for three years. It appears that the French boiler tube makers have not signed the international working arrangement just come to But a further meeting of representatives of the different nationalities is announced to take place in a month's time, and it is said to be probable that two French firms at least will them give in their adhesion.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

BARROW-IN-FURNESS, Thursday.

Hematites.

The hematite iron trade was dull even before the holidays, but it is now still quieter, because there is no disposition to do business until after the turn of the year, and then the outlook is none too assuring. Makers are not well fixed for orders, and, while the prompt trade remains very quiet indeed, the forward trade is practically of no account. There has been a further reduction in prices, and makers are now asking 67s. for mixed Bessemer numbers net f.o.b., while warrant iron net cash is at 66s. sellers, and 63s. three months. When trade is good forward prices are invariably higher than prompt prices, but the reverse is the case when trade is quiet. The lower prices now ruling are an indication that even lower values may be expected in the immediate future. At any rate, there are those whose opinion is most to be relied upon who do not take a gloomy view of the situation, and they think that not late in the New Year the demand for iron will again assert itself. Makers are therefore very careful to restrict their output as nearly as possible to the actual demand, and by that means to prevent stocks from accumulating. They are in all the stronger position to do this because there is no speculative business being done at present, and, further, the good trade of the past year has placed most of the smelting companies in the district in a very sound position financially, and they have as a consequence no need to sell iron for the purposes of stocking, and in order to realise money. The strange part of the position is that although stocks at the moment are at the lowest point on record, they are gradually being further reduced, and all the time are making for a position more and more statistically strong. Iron ore is selling slowly, and good average sorts are now down at 13s. 6d. net at mines.

Steel.

The trade in steel classes is very quiet indeed. The mills at Barrow are at a standstill in all departments, and it is not known whether they will start again until after the New Year, as the orders held are few, the demand is small, and the absence of large specifications in the market makes it clear that for some time to come there will be only partial employment for the mills in this district.

Shipbuilding and Engineering.

Vickers, Sons and Maxim have booked the order for a crane barge for Canada, and it is understood that they will have to build the British battleship Rodney, although no intimation is to hand yet of the official order having been placed. The Barrow firm are, however, the lowest tenderers. The engineering department at the large Barrow works are well off for orders, as new and important orders have lately come to hand.

Shipping and Coal.

There is a marked falling off in the shipping tonnage now being exported from West Coast ports. Coal and coke are being reduced in price week by week, and further reductions are imminent.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Holidays.

CHRISTMAS is the most important of the rest-times at the works, and it is being somewhat irregularly observed this season. At several establishments the holidays began after the close of work on Saturday, with the exception of the departments which had to be kept going on account of repairs, &c. Others continued over the Monday, and a few went on until Tuesday. Generally, however, the rule will be to take a full week's holiday. In the lighter staple trades of cutlery and silver-plating, &c., the general stoppage is expected to be about a fortnight. The miners' holiday will last, in the district around Sheffield, for the whole of this week, and it is intended to recommence work on the 30th inst. The active condition of the coal trade encourages a punctual resumption of operations in the collieries.

The Heavy Industries.

The year which is closing has been an active one in most of the heavy trades. Exceptions are military and marine material On account of the Government orders for armour plates having been insufficient to keep the whole of the Sheffield plant fully employed, that important department is now, and has been for some time, in need of fresh orders. These are not likely to be much longer delayed, but it is doubtful whether they will be placed this year. The continued depression in the shipbuilding yards accounts for the slackness in the demand for marine forgings and castings. The outlook in this respect for the early part of next year does not seem so bright as could be desired. In railway material there has been excellent business during the twelve months. The slight "easing off" reported in some quarters is, no doubt, of a temporary character, and not an unusual feature towards the end of the closing month. One of our largest railway material manufacturing firms report that it is as busily occupied as ever on tires, axles, springs, and similar material, and is now engaged upon extensions to increase its powers of production in the early future. A very satisfactory feature of railway rolling stock manufacture during the year has been the large demand from India and the Colonies. South America has also provided much work.

The Iron Market.

Activity has marked the demand for pig iron, more especially during the first half of the year, and some time later. In hematite the highest point was reached in mid-summer; in autumn it was evident that a decline was setting in, and prices this month show a considerable drop from the highest. We deal with Lincolnshire and Derbyshire in another paragraph. Even after prices of these irons began to decline, the orders placed were mainly—indeed, almost entirely—for immediate requirements. Of late, however, the easier quotations for brands locally used have induced more buying, and fair orders have been placed for delivery during the opening quarter of next year.

Lincolnshire and Derbyshire Irons.

A comparison of prices, showing the course of values in Lincolnshire and Derbyshire pig iron used in Sheffield and district nurseries, is interesting. At the quarter ending March 31st, No. 3 foundry was at 62s. 6d. per ton; No. 4 foundry, 60s. 6d.; No. 4 forge, 59s. 6d.; No. 5 forge, mottled, white, and basic, 63s. These prices remained until the 10th of May, when there was a rise of practically 2s. per ton all round. That continued until August, when No. 3 foundry was reduced by 2s.; No. 4 foundry, by 6d.; No. 4 forge, and No. 5 forge, mottled, white, and basic were unaltered. Since then values have been steadily falling up to the end of the year, the latest quotations being:—No. 3 foundry, 55s. 6d.; No. 4 foundry, 55s.; No. 4 forge, 54s. 6d.; and No. 5 forge, mottled, white, and basic, 55s. 6d. Derbyshire, No. 3 foundry, was 65s. per ton in January, 1907, falling to 63s. in June, and 57s. in December. At the corresponding period of 1906, the prices were 60s., 55s., and 65s.; Derbyshire, No. 4 forge, was 61s. per ton in January, falling to 60s. in June, and 55s. in December. In January, June, and December of 1906 the prices were 58s., 53s., and 63s. respectively.

Steel, &c.

The early and middle periods of the year were the busiest in the various departments of steel manufactures. In the latter half, though not until late in that part, there was somewhat of a shrinkage in fresh work, and this tendency has been accentuated towards the close of the present quarter. High-speed steels and tool steel generally have been in large request, but there has not been so much pressure recently, either on home or foreign account. In the lighter steel trades business has been well maintained throughout the year. It is a long time since files were in such continuously brisk request.

Belgian Steel Billets.

Considerable competition continues to be reported from makers of Belgian mild steel billets, which are stated to have been offered at from 90s. to 91s. and 92s. per ton.

The Coal Trade.

An excellent year in the coalfield is closing very firmly. The supplementary railway coal contracts, referred to last week, have not yet been arranged, so far as we have heard; but both as regards these and the contracts for the steam fishing trawlers a decision is expected very soon. It is not likely that the coal-owners will entertain any proposal for a lower rate than that now established for steam coal supplies—12s. per ton. This rate is exceeded in the open market. Gas coal contracts this year have advanced by 2s. 6d. per ton, and, as has been shown from week to week, manufacturing fuel and coking slack have been firm and in good demand. Coke is somewhat weaker in the last month—12s. 6d. to 13s. 6d. per ton for best washed; 11s. 6d. to 12s. 6d. per ton for unwashed. A striking feature of the year has been the increase in the number of patent coke ovens. House coal, which was a little weaker with the continuous mild weather, is now somewhat firmer, owing to the approaching holidays, and the necessity for obtaining supplies before "play" begins. Values are maintained at former quotations—best Barnsley commanding up to 13s. 6d. and 14s. per ton; secondary grades ruling from 12s. per ton.

NORTH OF ENGLAND.

(From our own Correspondent.)

Trade Prospects.

It must be acknowledged that the situation of trade in this district is not encouraging, and that there is a great contrast between the condition of business at the end of the first half and that at the close of the second half. It is not often that so rapid a change has to be reported. Six months ago the general tone of the market was optimistic; now most people take a distinctly pessimistic view of the situation, and it appears to be conceded that 1908 will be a quieter year than was either 1906 or 1907. Shipments are falling off, and consumers abroad are very slow about buying, for there is a general lack of confidence, and as the expectation is that lower prices will rule, it is considered advisable to purchase from hand to mouth only, and then any drop in quotations can be taken full advantage of. The blowing out of furnaces in Cleveland, Scotland, and the West Coast affords incontrovertible evidence of the slackening of business, as also do the closing of steelworks and shipyards. By the middle of January it is expected that the number of furnaces in operation in the North-East of England will have been reduced 20 per cent. as compared with the number blowing at the commencement of the last quarter of the current year. Makers certainly are not going to accumulate stocks, but have determined to regulate the production by the demand; they will not make more iron than the market requires, and that should enable them to keep up quotations and to get the cost of production down by bringing about a further cheapening in the prices of materials. The dearness of fuel and ore has been an unsatisfactory feature all this year, and has told badly upon the consumers of iron and steel, such as the ironfounders, the shipbuilders, the engineers, &c., who have been unable to increase their prices in the same proportion as materials have risen.

Shipbuilding.

That the shipbuilding industry is depressed does not admit of doubt, and the leading members of the trade state that the outlook is most unsatisfactory. There are too many steamers already built, and very few of them are making any profits for their owners, for rates of freight are wretched, and there is great competition for any freights that are offered. Added to the poor freights there is the heavy cost of working steamers, owing to dear fuel and high wages. Shipowners cannot afford to pay prices such as builders are compelled to quote for new shipping, owing to the heavy cost of materials, and it seems likely that there will be little new work forthcoming until the builders can quote something like £5 15s. per ton for new shipping. Very few ships are as yet laid up, but it is probable that it would be in the best interests of the shipowners if a number were put out of commission; there would not then be the scramble that now takes place for freight. There is one thing that keeps shipowners from ordering new steamers, and that is that they cannot generally induce investors to put more money into shipping when they can get little or no return for the money they have already invested. On Teesside and at the Hartlepools the various firms report the tonnages which they have launched in 1907, with indicated horse-power, as under:—

	No. of vessels.	G.R.T.	I.H.P.
Sir Raylton Dixon and Co.	10	28,350	19,585
R. Craggs and Sons	8	34,247	16,500
Ropner and Sons	9	32,127	16,550
Craig, Taylor and Co.	9	18,880	11,680
Richardson, Duck and Co.	13	32,204	13,690
Furness, Withy and Co.	9	36 608	—
Sir Wm. Gray and Co.	18	47,918	24,050
Irvine's Shipbuilding Company	7	25,530	11,300

Engineering.

Engineering is very dull, and it cannot be reported to have been brisk during the year. It did not share in the revival to anything like the same extent as iron and steel; and it was, indeed, the high prices that were quoted for these that has made it difficult for engineers to realise any profit on their working. Operations at some of the establishments have been rather slack, especially during the latter half of the year. It was announced at the annual meeting of the Cleveland Bridge and Engineering Company, Limited, Darlington, that the company had secured from the Sudan Government the order for the construction of a combined road and railway bridge over the Blue Nile at Khartoum, where the length of the waterway to be crossed is 1700ft. The undertaking represents the most valuable bridge contract ever placed for any part of the African Continent. The bridge is to be handed over to the Sudan Government by the end of 1909.

The Pig Iron Trade.

Very little business is being done this week in the pig iron trade, partly on account of the holidays; but the tone is rather better than it has been for some weeks; and it is an indication worth noting that the three months' price of Cleveland warrants is nearer the prompt than it has been for a considerable period. It is thought probable that prices will not go materially lower than they are at present, now that so many furnaces have been blown out, and that stocks are not to be allowed to accumulate. It was thought that there would be a considerable increase over the winter, and that prices would continue to go down; but the action taken by the ironmasters will counteract that. Thus, though shipments and inland deliveries have been considerably reduced this month, Connal's stock does not increase, on the contrary it is still declining substantially. The market is somewhat stiffer, but that is due not to increased demand so much as to reduced production. Makers quote 50s. per ton for early f.o.b. deliveries, and they are not disposed to accept more than a few pence less than for forward delivery, seeing that there will not be so much to offer, and that the production by the middle of January will in all probability be 14,000 tons per week less in this district than it was at September 30th, while in Scotland the output will have been reduced by over 3000 tons per week, and in Cumberland by upwards of 5000 tons. The decreased consumption of pig iron will thus be met by the smaller quantity available for sale. No. 1 is about 54s. per ton; No. 4 foundry, 49s. 6d.; and No. 4 forge, 49s. per ton. On account of the slackness in the steel trade the prices of East Coast hematite pig iron are still declining, and mixed numbers can now be obtained at 64s. per ton, but very few will buy, as they expect to see hematite iron relatively no higher than Cleveland pig iron, that is, mixed numbers hematite no more than 10s. above No. 3 Cleveland pig iron, that being the normal difference, though such a small difference has not been reported during the last two years; indeed, there has been as much difference as 24s., and it was that which kept plates

and angles at too high prices for shipbuilders. For long 81s. 6d. was the regular quotation for mixed numbers hematite iron, and makers in the circumstances could not then well accept less than £7 10s. for steel ship plates. Rubio ore is kept at 16s. 6d. per ton delivered c.i.f. Tees.

Manufactured Iron and Steel.

Trade is quiet and a good many of the works are idle this week for the holidays; they are more generally observed than usual, because of the dulness of trade. Some of the shipyards will be idle not only this week but also next. Producers have not yet seen their way to reduce their quotations, but it is expected that after the holidays consumers will be able to get cheaper iron and steel, especially as the raw material has declined in value—and that to a considerable extent. Common iron bars are now at £7 15s.; best iron bars, at £8 2s. 6d.; best best bars, at £8 10s.; steel and iron ship plates, £7; steel ship angles, £6 12s. 6d.; steel joists, £6 7s. 6d.; steel sheets, £8 10s.; galvanised and corrugated steel sheets, £13 2s. 6d., all less 2½ per cent. f.o.t. except the last named, which are less 4 per cent. f.o.b. Heavy steel rails, which have been as high as £8 17s. 6d. not this year, are now obtainable at £6 5s. net f.o.b.

Coal and Coke.

Not much change can be reported in any branch, but the tendency of prices is downward, and it is probable that next year consumers will not have so much to complain of dear coal as they have had during the year about to close. Best steam coals, which in the early autumn were at 16s 6d. per ton, can now be got at 15s. 3d., and best gas coals over the same period have dropped from 15s. 6d. to 13s. 6d. Furnace coke has been as high as 25s. per ton this year, but at the close can readily be obtained at 16s., which is the minimum of the year.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Holidays.

THE Glasgow iron market was open on Monday and up till mid-day on Tuesday, being afterwards closed until Friday morning. Similar arrangements will be observed next week in connection with the New Year holidays. As regards the iron and steel works, it is understood that the stoppage will be of longer duration than usual, owing to the slackness of trade, and in not a few other industries the holiday will also be prolonged.

The Warrant Market.

A small business has since last report been done in the pig iron warrant market. Cleveland warrants have sold at 49s. 4½d. to 49s. 3d. cash, 49s. 7½d. for delivery in seven days, 48s 3d. to 49s. one month, and 47s. 4½d. to 48s. 10½d. three months. A quantity of Cleveland warrants was recently sold at 66s. per ton, but the demand has since been practically non-existent. Warrants in circulation are much reduced, and the stock of pig iron in Glasgow warrant stores now amounts to only about 1200 tons. There is some expectation that stocks may soon begin to show an increase.

Output and Prices of Scotch Iron.

At the time of writing there are 87 furnaces in blast in Scotland, compared with 90 at this time last year, but it is expected that at least ten of the furnaces will be put of blast for some time. The prices of makers' pig iron are steady. G.M.B., No 1, is quoted at Glasgow 64s.; No. 3, 60s. 6d.; Govan and Monkland, Nos. 1, 61s. 6d.; Nos. 3, 61s.; Carnbroe, No. 1, 66s.; No. 3, 62s.; Clyde, No. 1, 67s; No. 3, 62s.; Gartsherrie, No. 1, 67s. 6d.; No. 3, 62s. 6d.; Calder, No. 1, 70s.; No. 3, 65s.; Summerlee, No. 1, 70s.; No. 3, 62s. 6d.; Langloan, No. 1, 75s.; No. 3, 70s.; Coltness, No. 1, 90s.; No. 3, 68s. 6d; Glengarnock, at Ardrossan, No. 1, 70s.; No. 3, 65s.; Eglinton, at Ardrossan or Troon, No. 1, 63s.; No. 3, 60s. 6d.; Dalmellington, at Ayr, No. 1, 65s. 6d.; No. 3, 60s. 6d.; Shotts, at Leith, No. 1, 69s.; No. 3, 64s.; Carron, at Grangemouth, No. 1, 72s.; No. 3, 64s per ton. Scotch hematite pig iron has been in comparatively poor request, and prices still tend lower, merchants now quoting 69s. 6d. per ton for delivery at the West of Scotland steel works.

Shipments of Pig Iron.

The shipments of Scotch pig iron in the past week were small, amounting to only 4358 tons, against 10,009 in the corresponding week of 1906. The aggregate shipments for the present year to date are 374,299 tons, being 31,381 tons more than in the same period of last year. The arrivals of pig iron at Grangemouth from the Cleveland districts were 5632 tons, against 13,055 in the corresponding week, showing a decrease of 7423 tons.

Finished Iron and Steel.

There has been a lack of orders in these departments in the last few days. Some of the works have been busy clearing off orders that have to be completed at once, but the prospects of work at the end of the holidays are so far quite indifferent. It is difficult to forecast what is likely to be the immediate future of the export business, inasmuch as increasing competition is generally expected both among home and foreign makers. Were wages reduced and also the prices of coal, there would be more likelihood of an early revival in business. The iron and steel manufactured goods imported into South Grangemouth and Glasgow during November amounted to 4120 tons, valued at £27,235.

Shipbuilding and Marine Engineering.

The departments which have turned out a large amount of tonnage during the year are now getting very slack, many workmen having been paid off, while there is very little fresh work coming to hand. The leaders of the operatives have decided to oppose the reduction of 5 per cent. in wages, and they call upon the masters to withdraw the notice of reduction; but the general impression is that this opposition is not likely to have any effect. One or two new contracts are announced, but they are quite inconsiderable in proportion to the work that has recently been completed. During the year 509 vessels have been launched from Clyde shipyards, with an aggregate tonnage of 619,919, being 21,098 tons more than in 1906. The total indicated horse-power of the engines constructed is 663,527, compared with 606,000 last year.

The Coal Trade.

The demand for house coal for home use is well maintained, but otherwise the trade is becoming quieter. Business is generally for present delivery, and no contracts of any consequence are being entered into for the future. There has been a great diminution in the business in connection with manufacturing qualities of coal, and the demand for shipment is also less active. Of course, a part of the dulness is due to the holidays, and it will not be possible until these are over to have any reliable evidence as to the state of business. Prices of all kinds of coal are steady.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

State of the Coal Trade.

CONDITIONS have remained much like those that were expected: prices about the same, with a fair quantity of tonnage coming in to all ports to secure coal before the holidays. On Friday there was a large clearance at Cardiff, fifteen vessels out of a number taking 55,000 tons; one was 6000 tons. On Saturday about 60,000 tons were despatched, though some vessels went away to Port Lémow, Huelva, and Stettin in ballast. The coal trade may now be expected to slacken, and shipowners are beginning to discuss the wisdom of laying vessels up in accord with the course taken in other quarters. It is not easy to forecast the trade following the holidays; some degree of slackness is likely, but I hear of January bookings at present prices. It will be noticed that little alteration has taken place in list prices since last quotations.

Latest Coal Prices.

At Cardiff, on Saturday, the attendance on 'Change was very small, and it was notified that very little business would be done this week, and that, in fact, until the first week of the new year not much would be done. Leading members have already left for their holidays. Latest prices given out must only be regarded as nominal, but they are sufficiently reliable to indicate the course of things:—Best large steam, 18s. 6d. to 19s.; seconds, 17s. 9d. to 18s. 3d.; ordinary large steam, 17s. to 17s. 6d.; best drys, 19s. to 19s. 6d.; ordinary drys, 18s. to 18s. 9d.; best Monmouthshire black vein, 17s. 3d. to 17s. 6d.; Western Valleys, 17s. to 17s. 3d.; Eastern Valleys, 15s. 9d. to 16s. 3d.; best house coal, 19s. 6d. to 20s. 6d.; seconds, 17s. 6d. to 18s.; No. 3 Rhondda, 19s. 6d. to 20s. 6d.; through, 16s. to 16s. 6d.; No. 3 smalls, 12s. 6d. to 13s.; No. 2 Rhondda, 15s. to 15s. 6d.; through, 11s. 6d. to 12s.; No. 2 smalls, 9s. 6d. to 9s. 9d.; best washed nuts, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d.; peas, 13s. to 13s. 6d.; seconds, 12s. 9d. to 13s.; best small steam coal, 11s. to 11s. 6d.; seconds, 9s. 6d. to 10s. 3d.; other smalls, including drys, 8s. to 8s. 6d. Patent fuel, 18s. 6d. Coke: Furnace, 18s. to 19s.; foundry, ordinary, 21s. to 23s.; special, 25s. to 27s. Pitwood is variable, one day firm to advance, and then retrograding. Newport is quoting 25s. to 26s.; Cardiff, 24s. 6d. to 25s.

Anthracite.

At Swansea on Saturday there was very little movement in trade. Coalowners had sold fairly well, and in view of the usual stagnation there was little chartering. The outlook is considered good for the future, but, as will be the case at Cardiff and Newport, resumption of work will not be until Friday, and then a short day. Latest prices are:—Best hand-picked malting, 29s. to 30s.; seconds, 27s. to 28s. 6d.; Swansea Valley big vein, 24s. 6d. to 25s. 6d.; red vein, 20s. to 21s. Machine-made coals:—Cobbles, 27s. to 28s.; nuts, 27s. 6d. to 28s. 6d.; peas, 14s. to 16s.; rubbly culm, 7s. to 7s. 3d.; duff, 4s. 9d. to 5s. Other coal quotations at Swansea were as follows:—Best large steam, 18s. 9d. to 19s. 9d.; ordinary large bunker, 14s. 9d. to 15s. 3d.; small, 8s. 6d. to 10s.; No. 3 Rhondda, 20s. to 20s. 6d.

New Miners' Agent.

On Saturday a meeting of the Executive Committee of the Miners' Federation for the Taff and Cynon district was held for the appointment of an agent for the district. There had been a large number of votes recorded, 4453 for Mr. Morell, Merthyr Vale; 1580 for Mr. J. Powell, Mountain Ash; and 1461 for Mr. Thomas Andrews, Treharris. Mr. Morell, who has come into prominence and shown a good deal of tact and capacity, was declared duly elected.

Colliery Rescues.

The initiative taken by the King promises to be largely followed in rewarding heroism shown in collieries. It will not be forgotten that the then Lord Mayor of London personally decorated the survivors of the Tynewydd calamity; but since that time recognition has been sparingly shown. Last week the accident at the Seven Sisters' Colliery, near Neath, was brought forward prominently by the presentation of a valuable memento to the managers of neighbouring collieries, and others who had taken part in the work of rescue. This was done by the proprietary.

Iron and Steel.

With the closing of the year the price list becomes of importance as foreshadowing the prospect of trade. Rails have not been a strong market, though the alteration in prices has not been great. Heavy rails are now at £6 5s. to £6 7s. 6d., while light ones, which continue in good demand for collieries, are at the usual extras, namely, £6 15s. to £6 17s. 6d. The price of bars has been lowered, and is expected, says a leading agent interested in the trade, to tell favourably upon demand. This has increased of late at the principal works. Bessemer bars are at £5 to £5 2s. 6d., and Siemen, £5 2s. 6d. to £5 5s. The following prices of pig iron are quoted in the district:—Scotch, 58s.; Clevedon, 49s. 1½d.; hematite, 63s. 1½d.; Welsh hematite, 72s. 6d. Iron ore still easy at 15s. 6d. to 16s. for Rubio; Almeria, 15s. to 15s. 6d. A second class Rubio is being offered at Cardiff for 14s. 3d. to 14s. 6d. Cargoes have come in from Sundswall for Ebbw Vale, and from Bilbao to Guest, Keen and Co. Several cargoes of pig iron came in last week, principally to Swansea from Grimsby, in quantity 2000 tons; one large consignment to Gilbertson. It is estimated that the export to Wales from the Tees during the year has been 13,000 tons.

Dock Extension, &c., at Cardiff.

An important extension and equipment at Penarth, the flourishing adjunct of Cardiff, is given by the Taff Vale Company's scheme. This has been deposited, and solicits powers to provide sufficient accommodation for the repair of steam and other vessels in connection with their Penarth Harbour and Dock requirements. By the second clause powers are sought to construct, &c., floating pontoons, gridirons, slipway, shipbuilding, and ship-repairing yards, sheds, and engineering works for the repair of steam and other vessels.

Tin-plate.

Good work has been done both at mills and at port, against a certain holiday slackness. From the works 78,352 boxes were shipped and 83 951 boxes despatched, leaving stocks reduced to 125,948. The reduction in price of raw materials has been a benefit to manufacturers. Tin has been as low as £122, but I note that forward prices are at £124. Prices of ordinary coke, last list issued, were 12s. 6d., ternes at 25s. and cheaper down to 24s. Oil sizes not in strong request. Nominal quotations:—I.C. 14 by 16¼ and 14 by 19½, 12s. 9d.

The November Coal Trade.

In the compilation of the coal totals from Wales for the year the extent of business during one of the busy months—November—was as follows:—In cargo from Cardiff, 201,684 tons; bunkers, 8543 tons; from Newport, cargo, 67,251 tons; bunkers, 2348 tons; from Swansea, cargo, 24,234 tons; bunkers, 4103 tons; from Port Talbot, cargo, 19,464 tons; from Briton Ferry, cargo, 21,505 tons; bunkers, 976 tons; Llanelly, cargo, 5414 tons; bunkers, 414 tons.

A Suggested Mineral Traffic Arrangement.

An able authority in the Cardiff district has written strongly in favour of a mutual arrangement betwen the Taff Vale, Barry and Rhymney, suggesting combined action in respect of dock dues. This is regarded as likely in the near future.

NOTES FROM GERMANY.

(From our own Correspondent.)

Rheinland-Westphalia.

THE iron industry in most departments has been but moderately active during this week and the last, and a downward tendency in quotations could be noticed. The Steel Convention resolved, on the 4th inst., to raise the export bounty for semi-finished steel from M. 5 to M. 15 p.t. The Wire Rod Convention has reduced the export price for wire rods M. 7·50 p.t., the present quotation being M. 117·50 p.t. Also the Luxemburg-Lorraine office for sale reduced the prices of forge pig M. 10 p.t., the ruling quotations now being M. 54 p.t., and, according to a report from Düsseldorf, the steel masters reduced semi-finished steel and sectional iron M. 10 p.t., too. In the hoop trade, also, the condition has become unsatisfactory, and makers find it more difficult every week to obtain orders, and they have had to reduce prices in a number of instances, just to induce manufacturers to buy more freely. Very few orders on foreign account could be obtained last week, and quotations are unremunerative, in spite of the reduced prices for semi-finished steel. A dull tone characterises the pig iron market. The Union for the sale of Siegerland pig iron has, according to the *Cologne Gazette*, reduced the price of spiegeleisen M. 5 p.t. for the first quarter of 1908. Large lots of spiegeleisen for delivery next year have already been booked. The employment of the bar and plate mills in the Siegerland is rather languid, and the last-named mills have been compelled to restrict their output. The marked downward tendency in the iron business has already been the cause of reductions in wages too. The Bremer Works, of Weidenau, and Kaiser and Co., of the same place, have announced a reduction of 12 per cent. from the 1st inst. The building line is entirely lifeless now, and the girder trade consequently has been decreasing from week to week.

The Silesian Iron Market.

Demand and employment show weakness, and makers are running short of orders. Quotations are anything but stiff, manufacturers often taking much lower prices than are actually ruling to secure fresh work. The trade on foreign account is but limited.

Coal in Germany.

Consumption in all sorts of fuel continues pretty active, and the tendency of the market is strong. A change is not expected to take place for the next few weeks. In a number of instances the blast furnace works are reported to have revoked orders in coke, owing to the quieting down in the iron trade. A most animated inquiry is experienced in the briquette trade, where supplies, though heavy, have often been found insufficient, because demand increases rapidly.

Iron and Steel in Austria-Hungary.

Though German competition is very keen, the business done generally has remained satisfactory, and the tone is fairly hopeful still. Platemakers try to beat their German rivals by reducing quotations as much as possible, and very little is gained in this branch of business. Prospects in the railway and engineering department are bright. The State Railway requirements in rails and general railway rolling stock exceed last year's demand considerably, and the locomotive and wagon-building establishments are looking forward to being actively engaged during the greater part of next year. Marine requirements are also pretty large. In export a downward movement is felt. A regular and remunerative business is being done on the Austro-Hungarian coal market. Consumers continue to complain of the want of wagons and of the slow deliveries.

Unfavourable Condition in Belgium.

An increasing German competition and an abatement in the home demand have caused the weak tone in the Belgian iron industry to become more marked than before. In the plate trade demand is dull and offers increasing. The concessions in price that are being granted in the girder trade have also extended to other branches now. Raw material, as well as semi-finished steel, have not shown any change in price since former letters.

The Belgian Coal Market.

The business transacted in engine and house coal is very lively still, and as many sorts of coal remain scarce the position of prices has been firm, as before. Prospects generally are, perhaps, less bright than in the beginning of the quarter, for the dulness in the iron industry cannot be without a depressing influence on the coal trade after some weeks. Even now ironmasters only reluctantly sign large contracts in coal for forward delivery. The second quarter of next year will most likely bring a downward movement in the prices for coal; the majority of the larger contracts end with the month of March, and for fresh orders consumers are sure to pay less than has been hitherto given.

Iron and Coal in France.

The market for iron and steel is very languid and dull; only in a few specially favoured cases have manufacturers been able to get in a fair supply of fresh work. Prices are, naturally, weak. The coal trade is pretty lively, and firm. The movement of the colliers in the Nord and Pas de Calais Departement—which aims at a reduction of the working hours, or, if possible, raised wages—is causing disturbance among the coalowners of France.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. C. ROUS-MARTEN has removed from Eldon-chambers, 30, Fleet-street, to new offices at 130, Fleet-street, E.C.

OWING to the existence of doubts as to whether the control of the Wellman-Seaver-Morgan Company, Limited—although registered in London—is in reality in English or American hands, the company has decided to bring the name of its managing director into the title of the company, which will in future be called "Wellman, Seaver and Head, Limited." We are asked to state that the company has recently formed a special furnace department, and also an electrical department, for dealing with their special controllers and brakes.

CONTRACTS.—Another motor steam fire engine of the Fire King type has just been delivered to the Fire Brigade Headquarters in Southwark Bridge-road by Merryweather and Sons, Limited. —The Continuous Rail Joint Company, Limited, has received an order from the contractors, Messrs. J. G. White and Co., Limited, for its patent continuous rail joints for Llanelly, also repeat orders for this fastening on Messrs. White's lines at Montevideo.—L. P. Winby and Co. have recently been favoured with an order from the Cardiff Corporation Tramways for a supply of their Winby patented anchor chairs.

YORKSHIRE ENGINEERING STUDENTS.—On the 20th inst. Mr. F. W. Dick, general manager of the Parkgate Ironworks, Rotherham, gave an address to the Yorkshire section of the student members of the Institution of Civil Engineers at the Technical Department of the University of Sheffield. The subject was "The Utilisation of Waste Energy in Iron and Steel Works," which he considered under five heads—Waste of energy (1) of position, (2) of motion, (3) of fluid pressure, (4) of heat, and (5) specially waste of the energy of blast furnace gases. Mr. Dick, after dealing with the different points, stated that in all these devices, however, the limitations of temperature interfere with efforts to prevent the loss of energy. Why, then, it might be asked, did engineers not work with more efficiency to begin with? The answer was that it was not the object to get the last degree of heat out of a pound of coal, but to keep machinery running continuously for the main purposes of the works. All improvements must justify the expenditure upon them, and unless they could do that the practical engineer could not consider them. A hearty vote of thanks was accorded the lecturer.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS**, *M.I.Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

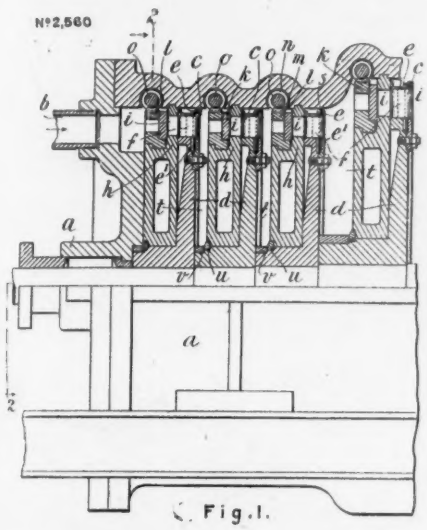
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

TURBINES.

2560. February 1st, 1907.—IMPROVEMENTS IN OR RELATING TO TURBINES, Richard Cramp, of 53, Dee-street, Brunswick-road, Poplar.

This invention relates to turbines of the type in which the blades of the rotary member are pivoted so that their angle can be altered automatically, by the steam against suitable stops, for the purpose of reversing the direction of running, the oppositely disposed sets of guide vanes being provided with means whereby those admitting steam in one direction can remain open and the remainder be closed. There are four figures. Fig. 1 is a sectional side elevation of a part of a turbine; *a* is the casing, and *b* is the steam inlet; *c c* are the wheel or rotor blades, which are mounted on wheels or discs *d d* and followed by an expansion or distributing space, as in the Rateau type of impulse turbine, which type it has before been proposed to adapt to a reversible turbine having pivoted blades and adjusting and limiting pins or stops carried by them. Each blade is pivoted on pins *e*, e^1 near the end, remote from the guide vanes, while the other end is free to swing through

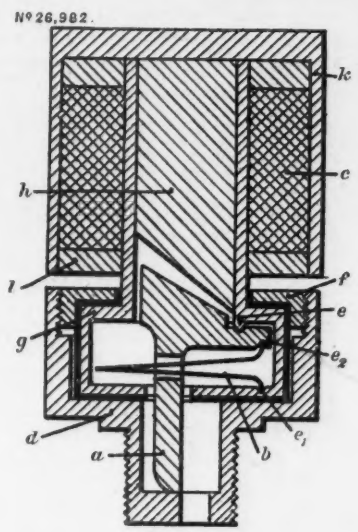


a sufficient angle to permit the motive fluid to act on one side or on the other, so as to drive the turbine in either direction as desired. Stops *f f* are placed between the blades to limit their movement, and such stops are of a curvature suitable for preventing any interruption of the flow of fluid. Each side of the blade presents a continuous curve to the motive fluid, so that the latter can act thereon at the most efficient angle for impulse action during its passage through the blades, and the end of the blade nearest the guide vanes is bifurcated or forked. Between the rings of wheel blades are stationary guide rings *k* carrying the guide vanes *i*. Against the face of the guide rings is fitted one or more slidable segments *k*, constituting a valve, and adapted to be so adjusted relatively to the guide rings as to cover either the forward or the reversing vanes, or partly both, at the period of changing. The means for holding and adjusting these segments consists in providing them with pins fitting loosely in holes in rings *l* having worm teeth *m*, with which engage worms *n* mounted on shafts *o*, by which they may be turned in either direction from a common shaft to cause the segment to cover the sets of vanes for one direction and to uncover the oppositely disposed sets; *t* are the distributing or expansion spaces for the individual sets of blades, and *u*, *v* are packing pieces and rings respectively, which serve to prevent steam leaking from the expansion spaces *t* through the junction between the stationary frame and the hubs of the rotary discs *d*. In operation the fluid from the directing set of guide vanes in use strikes the bifurcated edges of the blades of the rotor, and throws such blades over against the limiting stop *f* to the rear of each blade, so that the fluid has a free passage between the blades, and is directed rearwardly, after which it passes to the expansion space *t* prior to entering the next valved guide ring. The curvature of the blades at both their front and rear edges is such as to enable them to catch the impinging fluid on the front edge, while angular direction of the guide vanes will be such that the rearward leg of the bifurcated front edge will be out of line of or below the edge of the forward leg when the fluid is acting on it for driving purposes.—*December 6th*, 1907.

INTERNAL-COMBUSTION ENGINES.

26,982. November 27th, 1906.—IMPROVEMENTS IN ELECTRO-MAGNETIC IGNITION DEVICES FOR INTERNAL-COMBUSTION ENGINES, *Robert Bosch*, 11-13, *Hoppenlaustrasse, Stuttgart, Germany.*

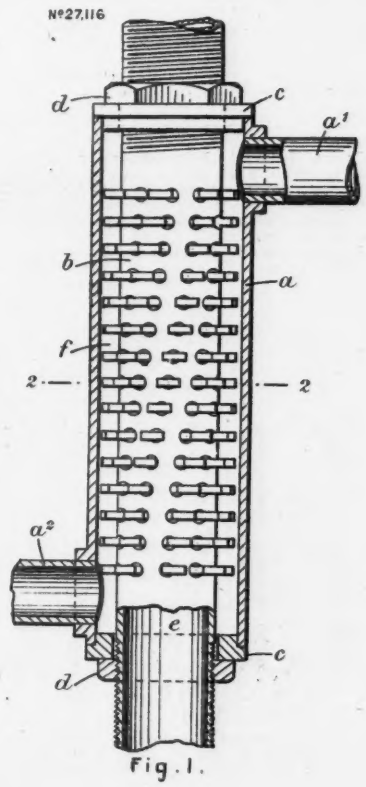
Electro-magnetically-operated contact breakers for the ignition apparatus of internal-combustion engines are known in which one arm of the contact breaking lever forms the armature of the electro-magnet and rocks on a stationary pivot, being returned to its normal position by the action of a spring. With apparatus of this kind the rocking lever requires lubrication if the apparatus is to act with the necessary precision. The difficulty, however, is encountered, that no lubricant can be found which successfully withstands the high temperatures prevailing within the combustion chamber during the operation of the engine. This invention consists in the use of knife-edge bearings for all turning points of the system—that is, the pivot of the rocking lever itself and the points of engagement of the spring that effects the return with a stationary part of the ignition device and with the rocking lever. There are three figures. Fig. 3 is a longitudinal section; *d* is a screw-threaded plug *d* and tightly secured thereto by a countersunk nut *f* is the flanged end of a sleeve *g* made of brass or any other suitable non-magnetic material. The sleeve *g* is partly filled by the stationary iron core *h* and is surrounded by the winding *c*, which in its turn is surrounded by a cylindrical extension *k* of the iron core hermetically sealed at the lower end by a plate *l*. On a knife edge *e* is fulcrumed the rocking lever *a*, one end of which forms the armature of the electro-magnet, while the other is pressed against the lower end of the plug *d* by a V-shaped spring *b* likewise mounted at each end on knife edges e^1 and e^2. When the apparatus is to be operated one end of the winding *c* is connected with the iron core of the magnet, and, therefore, through the knife edges and the spring with the rocking lever *a*. The other end of the winding is connected with one pole of a battery



or other source of electric current of which the other pole is connected with the body of the engine, and, therefore, with the plug *d*. When the circuit is closed a current passes from the battery through the winding *c* to the iron core, from there to the lever *a*, thence to the plug *d* and back to the battery. The electro-magnet is energised attracts the armature, and thus rocks the lever *a* and interrupts the current at plug *d*, where in consequence a spark is generated.—*December 6th*, 1907.

27,116. November 28th, 1906.—IMPROVEMENTS IN VAPORISERS FOR INTERNAL COMBUSTION ENGINES, Thomas G. Slipper, of Blofield, Norwich.

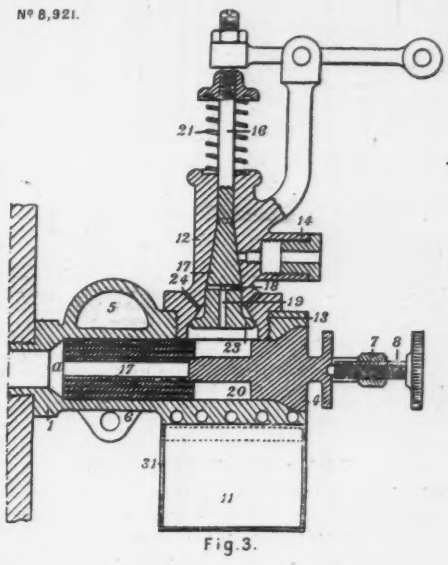
This invention relates to vaporisers of that type which are heated by the exhaust gases, and has for its object to utilise the heat to greater advantage than hitherto, also to ensure the thorough atomising of the hydrocarbon mixture, and consists in fixing in or forming on the dividing wall through which the heat of the exhaust gases is transferred to the hydrocarbon mixture, and a



series of metal studs arranged to project on opposite sides of the wall into the paths of the exhaust gases and hydrocarbon mixture respectively. There are two figures. Fig. 1 is a sectional elevation of a vaporiser. The vaporiser is of circular form in cross section, and comprises a tubular casing *a* and an inner concentric tube *b* centered on the casing *a* by end closing and distance rings *c*, and fitted by nuts *d* screwing on the tube *b*. The tubes *a b* thus form a central compartment *e*, through which the exhaust gases are passed, and an outer annular compartment *f*, through which the hydrocarbon is fed to the engine. The dividing wall or tube *b* between the compartments *e f* is perforated with screw-threaded openings, into which copper pins or studs are screwed, and project both sides of the tube. The tube *b* is connected at one end with the exhaust pipe of the engine, so that the exhaust gases pass through the tube, whilst the casing *a* is provided with inlet and outlet pipes a^1 a^2, the inlet being connected with the carburetter which supplies the hydrocarbon mixture to the chamber or compartment *f*. The hydrocarbon in its course to the induction valve of the combustion chamber of the engine has to pass very rapidly all the heated projections or studs, and consequently must be thoroughly vaporised and atomised.—*December 6th*, 1907.

8921. April 17th, 1907.—IMPROVEMENTS IN METHODS OF, AND APPARATUS FOR, CHARGING INTERNAL COMBUSTION MOTORS, *Leon A. Marthe, of 24, Rue du Champ de Mars, Paris.*

This invention is based upon the principle of a rapid vaporisation of a liquid which is atomised under a high temperature and a very low pressure. During the suction stroke of the piston in the cylinder, it is easy, by temporarily keeping all the valves closed, to attain a degree of vacuum which is sufficient instantly to vaporise even a heavy liquid hydrocarbon—which has been previously heated and atomised to a high degree—and to obtain a very complete volume of explosive mixture by letting air enter through the valve openings during the remaining part of the stroke. From the preceding it follows that the four-stroke cycle is altered in its first stroke. There are ten figures. Fig. 3 is a vertical longitudinal section. The apparatus comprises a main body 1, traversed from one side to the other by a cylindrical passage, adapted to receive a vaporiser *a*. This passage 2 can be formed with straight or helical grooves, if the periphery of the vaporiser to be fitted in it is smooth, and has a conical seat to receive the conical head 4 on the vaporiser *a*. The passage 2 is surrounded by another channel 5, through which the exhaust gases are circulated, and which is provided at each of its ends with a connecting flange 6. The vaporiser is held in its place by means of a movable stirrup 7, provided

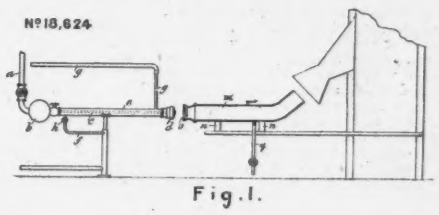


with a binding screw 8 and two pivots. Beneath the main body 1 guides are arranged to support and maintain a heater 11, or any other device for preliminary heating, adapted to facilitate the starting of the motor with heavy oils. A guide 12 is arranged on the body 1, screwed on to the former, as shown at 13. This guide can be directed in such a manner that the stay supporting the tilter or lever enables the latter to be operated either by thrust or tension. The guide 12 is provided with a gland 14, wherein is mounted an adjustable pin or screw for regulating the flow of the liquid. On the same boss as the gland there is provided a male connecting screw, adapted to receive the female connecting screw of the tube leading the liquid combustible from the reservoir to the distributing apparatus; 12 is perforated, and traversed by a channel, the shape of which corresponds to that of a special distributing valve 16 for the liquid. The valve 16 is guided by its upper rod and by a cylindrical part below the conical valve 17 of the petroleum inlet channel 15. Channels 18 converge towards the central channel 19, which leads the liquid into an annular chamber 20, within which the vaporiser is arranged. The conical valve 23, provided at the lower end of the cone 17, is adapted to present a greater surface to the draught caused by the vacuum in the case of automatic working. One or more small passages 24 are provided for working with light hydrocarbons; they contribute, owing to the passage they allow to the air, to a more energetic distribution and to the inflammability of the hydrocarbon vapours during their passage through the channels of the sprayer.—*November 29th*, 1907.

PRODUCING ELECTRICITY.

18,624. August 20th, 1906.—IMPROVEMENTS IN THE METHOD OF AND APPARATUS FOR PRODUCING ELECTRICITY BY STEAM Henry E Fry, of Godmanstone, Dorchester.

The object of this invention is to produce electricity by steam without employing either engine or dynamo. The fact that electricity could be produced by steam without engine or dynamo was proved by the late Lord Armstrong and by Faraday more than sixty years ago, but the discovery was only of scientific interest



and led to no practical or useful results, because with the apparatus employed only a small quantity of electricity was produced compared with the steam power which was expended. The object of this invention is to increase the quantity. The boiler, which is well earthed, is placed in a suitable house or position outside, but immediately adjoining the building in which the electricity is produced. The steam is conveyed from the boiler by means of a steam pipe to a steam chest which is placed within the building in which the electricity is produced. To the end of each steam pipe is secured a nozzle which consists of a pipe having across it two or more diaphragms at a small distance apart. The first diaphragm has in it a narrow slit, and the second diaphragm a row of holes the total area of which is, say, three times that of the slit. The third diaphragm is constructed of two plates adjustably fixed outside the nozzle and a short distance away from the last diaphragm, so that the width of the slit between their two edges can be varied. At a short distance from the nozzle (thus leaving an air gap) is placed a well-insulated pipe to receive the now electrified moistened steam, and within the pipes or conduits are placed rows of pointed metallic collectors to collect the electricity

which has been produced by and carried forward by the steam across the air gap. There are ten figures. Fig. 1 is an elevation of the apparatus The boiler may be of any ordinary construction. Fig. 5 is a horizontal section of one of the nozzles ; *a* is the steam pipe from the boiler and *b* is the steam chest ; *c* are pipes leading steam from the chest *b* to the nozzles *d*. Each of the pipes *c* passes through a water jacket *e* provided with an inlet pipe *f* and an outlet pipe *g* ; *h* are cocks on the pipes *f* by which the flow of water through the jackets *e* and consequent condensation of the steam in the pipes *c* can be separately regulated. The nozzles *d* each have in them two diaphragms *j* and *k*. The diaphragm *j* has in it a narrow horizontal slit, say, ·008in. wide and 1125in. long,

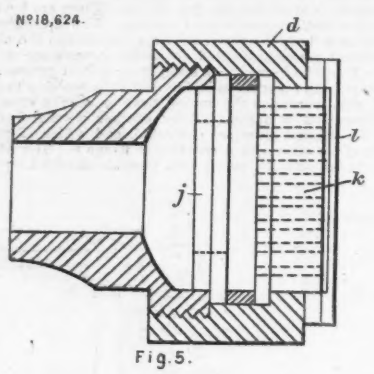


Fig. 5.

whilst the diaphragm *k* has in it a horizontal row of holes, say, $\frac{1}{16}$in. in diameter. It is important that the slit and the row of holes should be horizontal, otherwise the condensed water carried by the steam passes mainly through the lower portion, and there is a consequent diminution in the quantity of electricity produced. In front of the diaphragm *k* is a third friction surface consisting of a slit formed by a pair of horizontal wires *l*. The steam escaping from the nozzles *d* enters a conduit of galvanised iron and is supported on insulators *n*. The mouthpiece of the conduit *m* has in it collectors *o* which consist of series of parallel vertical and horizontal serrated strips of brass having their ends soldered to a ring, which in its turn is soldered in the mouthpiece. The conduit *m* is provided with drain pipes *q* to get rid of condensed water. The steam escaping from the conduit *m* passes away by the chimney *r*.—*December 5th*, 1907.

ROAD MOTOR VEHICLES.

3277. February 9th, 1907.—IMPROVED MEANS FOR STEERING MOTOR ROAD VEHICLES, Henry B. Molesworth, 39, Victoria-street, S.W.

The object of this invention is to provide improved means for steering motor road vehicles. In this invention, behind the axle of the driving wheels, an additional axle is fitted carrying two additional steering wheels, connected together by cranks and a link in the ordinary manner. This axle is held at a fixed distance from the driving axle, to which it is connected by rigid distance rods which allow the axles to move independently of one another in approximately vertical planes while maintaining the distance between them constant. The weight of the vehicle is borne by compensating beams pivoted to the frame in such a way that the load is distributed between the two axles. There are two figures. Fig. 1 is a diagrammatic plan view of the steering gear ; *a* is the axle of the driving wheels *b b*. This axle is coupled by distance

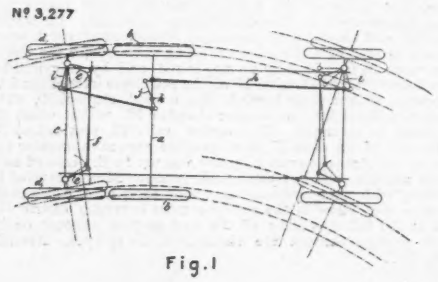


Fig. 1

rods or links to fixed pins which are in proximity to the axles of the sprockets, by which the chain wheels fast with the driving wheels are to be driven. The slackness of the endless chain thus remains but little altered whether the axle of the driving wheel lifts or descends. Behind the axle *a* there is an additional axle *c* carrying two additional steering wheels *d*, one at each end, connected together by crank arms *e* and a link *f* in a similar manner to that in which the ordinary front steering wheels are connected. This axle *c* is held at a fixed distance from the driving axle *a* to which it is connected by rigid distance rods which allow one axle to move up when the other moves down. The two axles are near each end coupled by links to the ends of a longitudinal compensation beam pivoted at some intermediate point of its length to the frame. A link *h* passes rearwards from the end of an arm *i* fixed on the vertical axis of one of the front steering wheels and is pivoted to one arm of a lever *j* fulcrumed beneath the axle *a* of the driving wheels at *k*, while the other arm of the lever is linked to an arm *l* on the vertical pivot of one of the rear steering wheels *d d*. When the lever *j* is in its central position the ends of its arms are vertically below the axle *a*. When the axle is lifted it is also moved further away from the end of the arm *i*, but the axle when lifted is also tilted and the end of the longer arm of the lever *j* to which the end of the arm *i*, is linked moves forwards, so that in place of being moved in an arc of a circle corresponding to that in which the axle moves, it moves in a flatter arc which is concentric with the end of the arm *i*, so that the lifting of the axle does not cause any turning movement to be given to the lever *j* and the relative positions of the front and rear steering wheels remain the same. Similarly, if the driving axle *a* descends the axle is carried towards the end of the arm *i*, but is tilted in the opposite direction so that the same end is attained.—*December 6th*, 1907.

LOCOMOTIVES.

26,369. November 21st, 1906.—IMPROVEMENTS IN THE CONSTRUCTION OF MONORAIL LOCOMOTIVES AND THE LIKE, Alexander T. Penney, 107, Fenchurch-street, E.C.

In monorail locomotives where the whole or the greater portion of the weight of the vehicle is taken on the rail wheels, of which each locomotive has two or more, this invention relates to an economical method of constructing the boilers or steam generators, and at the same time the construction is such that the balance of the truck is maintained. Two generators, A and B, are placed side by side of horizontal type, and so fitted on the truck that in conjunction with the water tanks, fuel and underframe, the desired balance is obtained. There are two figures. The drawing illustrates a type of monorail in which approximately 90 per cent. of the total weight is taken by the rail wheels running on the single rail track, and the remaining weight on the road-wheel D.

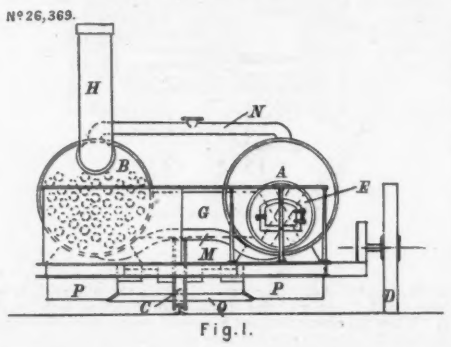


Fig. 1.

Of these generators, one of them has a combustion engine E, arranged in such a way that the fuel is burnt in same, the hot gases passing through a flue and then by means of a suitable passage G, into the other generator B. This second generator is constructed with tubes for the hot gases to pass from one end to the other, and then into the atmosphere through the chimney H. For ordinary working, the fuel is used on the grate bars in the combustion chamber E, but for the purpose of quickly raising steam for starting, the other generator may be arranged with fire bars in B, and fuel fed on to same from the driver's platform. These generators are connected one to the other by means as at M, to permit the water passing freely from one generator to the other, so as to maintain a good circulation and to keep the level of the water equal in both generators, and to draw off steam for the engine. One is connected to the other by a steam drum or by a steam pipe as shown at N, from which the steam is drawn for the engine, which is placed in any convenient position for driving the truck. The water tanks are placed in the underframe as at P, and connect them by pipe or pipes Q, so that an equal level of water is maintained.—*December 6th*, 1907.

GAS PRODUCER.

1313. January 18th, 1907.—IMPROVEMENTS IN CONNECTION WITH GAS PRODUCERS THAT ARE FOR USE WITH BITUMINOUS COAL OR OTHER FUEL CONTAINING VOLATILE MATTERS, John S. Daniels, Fern Cottage, Lightpool, Stroud ; Edward P. Higgins, Tyn-y-rheol, Rooksmoor, Stroud ; and Frederick L. Daniels, 1, Clarence-villas, Lightpill, Stroud.

This invention relates to gas producers for use with bituminous coal or other fuel containing volatile matters, the object being to

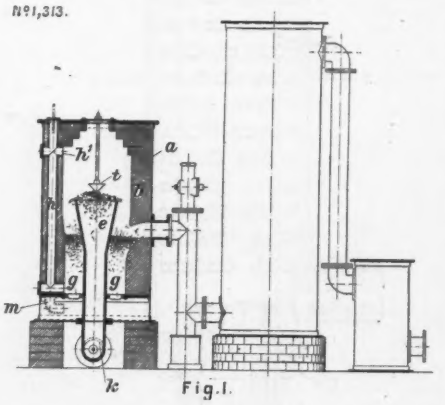


Fig. 1.

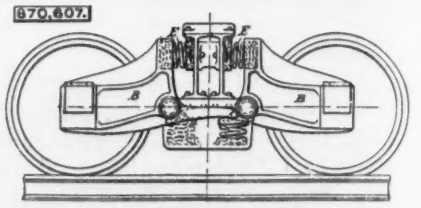
provide efficient means for collecting and utilising the distilled and condensible gases from the fuel. There are two figures. Fig. 1 shows in part section a side elevation of a gas-producing plant with the producer arranged in which the volatile gases are carried through the fire. A casing or enclosing shell *a* of metal within which is built up a firebrick lining *b* has fitted a feed hopper having a valve and feeding hopper tube. The latter communicates with a receiving chamber or receptacle *k* below the fire-bars *g* of the producer and connects to the retort *e*. The retort *e* passes through the fire, the end being open and having a spreading device *t* arranged at a suitable distance above the opening, so that the fuel will pass out freely and feed the annular fire round the retort, and from which the distilled gases and vapours may be drawn or allowed to escape by means of an opening or openings h^1 leading thereto. The fuel is fed through the retort *e* by means of a screw *s* arranged at the lower end thereof. The distilled gases and other products escaping from the upper end of the retort *e* is collected by means of an opening h^1 which leads into a condnit passage or pipe *h* that may be carried down within the material forming the lining *b* of the producer ; or by means of an independent exhaust pipe or pipes ; or the distillation products may be carried away through a suitable cleaning plant with the ordinary producer gas from the annular fire around the retort. The lower end of this pipe *h* joins to a feeder branch which delivers the distillates and gases in the lower portion of the fire-grate *g* within the zone of combustion or below the fire-grate *g* with a feeder *m*.—*December 14th*, 1907.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

870,607. CAR-TRUCK, *W. E. Amberg, Chicago, Ill.—Filed April 1st*, 1907.

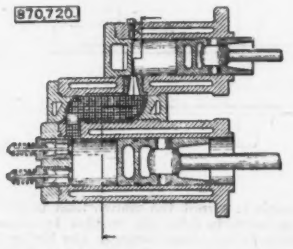
Each bearing is carried in a cantilever bracket B, pivoted at D ; coiled springs are placed at E E, bearing on the transome.



Further elasticity is provided by springs under the inner tails of B B, as shown. There are sixteen claims.

870,720. *Internal-combustion Engine, A. J. Frith, New York, N.Y. —Filed April 17th*, 1905.

We have here a modification of the old Stirling hot-air engine, in that a regenerator is used. The cycle is rather complicated. The action is fairly well stated in the seventh claim, which runs as follows :—In an internal-combustion engine, the combination with a pair of cylinders, each provided with a movable working piston,



one of said cylinders constituting the compression cylinder and the other the combustion chamber, of means for supplying moisture to the charge early in the compression, a regenerator connecting said cylinders, and means for operating said pistons to force the compressed charge through the regenerator into the combustion chamber, allowing the gases to partially expand in said combustion chamber, return through said regenerator and further expand in said compression cylinder. There are ten long claims.

THE COMMERCIAL MOTOR USERS' ASSOCIATION.—Although the weather was not all that could be desired a large number of commercial motor vehicles assembled on the Thames Embankment on Saturday afternoon last, December 14th, 1907, the line of vehicles extending from Waterloo Bridge to beyond the Temple District Railway Station. The occasion was the final adjudication of the judges of the Commercial Motor Users' Association in connection with the *Commercial Motor* prize scheme for good driving, which had been organised by the Association. The object of the scheme has been to encourage drivers of commercial motor vehicles, by means of money prizes, to keep their vehicles in the best possible condition, to run them without accident, and to devote to their work all possible care and skill. In this way, the owners of the vehicles, as well as the vehicles themselves, will benefit. Although it is proposed to extend the scheme to other centres next year, it has been limited this year to drivers who worked in or into the London area (a radius of 20 miles from Charing Cross), driving steam lorries and tractors which had been in use for a period of not less than twelve months, and which had travelled a distance of not less than 4800 miles. Each of the drivers had previously undergone a verbal examination as to his knowledge and experience of his machine and his knowledge of driving and of traffic conditions, and the present muster was to enable the judges to examine the condition of the machines before awarding the prizes.

END OF VOL. CIV.

GENERAL LIBRARY,
UNIV. OF MICH.
JAN 9 1908

The Engineer.

Registered as a Newspaper

OFFICE FOR ADVERTISEMENTS AND PUBLICATION, 33, NORFOLK STREET, LONDON, W.C.

VOL. CIV.—No. 2713] LONDON: FRIDAY EVENING, DECEMBER 27, 1907 [PRICE SIXPENCE

India-office, Whitehall,
23rd December, 1907.

The Secretary of State for

India in Council is prepared to receive TENDERS from such persons as may be willing to SUPPLY—

BEARING PLATES.

The conditions of contract may be obtained on application to the Director-General of Stores, India-office, Whitehall, S.W., and Tenders are to be delivered at that office by Two o'clock p.m. on Tuesday, the 7th January, 1908, after which time no Tender will be received.

E. GRANT BURLS,
Director-General of Stores.
929

India-office, Whitehall, S.W.,
20th December, 1907.

An Assistant Foreman

STEEL MELTER, for OPEN-HEARTH FURNACES, is REQUIRED for the Gun and Shell Factory, Cossipore, near Calcutta.

He must be not less than 25 years of age, and possess experience of both the acid and basic processes, and some knowledge of Foundry practice in general.

Engagement for five years, with the option of extension if approved by the Government of India.

Salary, Rupees 355, rising by annual increments of Rupees 10 to Rupees 395 per mensem for the first five years, and rupees 425 per mensem thereafter; the value of the Rupee may be taken at about 1s. 4d.

Free quarters, free medical attendance, and free passage out and home for himself and family (if any).

Further particulars and forms of application can be obtained from the DIRECTOR GENERAL OF STORES, India-office, London, S.W., not later than 15th January, 1908.

Applications for forms should be marked on the envelope "Steel Melter."
933

PATENTS, DESIGNS, AND TRADE MARKS ACTS, 1883 to 1902.

Notice is Hereby Given that

WILHELM MAUSS, of the Rand Central Electric Works, Brakpan, in the Colony of the Transvaal, Mechanical Engineer, SEEKS LEAVE to AMEND the SPECIFICATION of Letters Patent No. 5022 of 1906 granted to him for "Improvements in in Percussive Machines and Tools, operated by Expansible Fluid."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents) issued on the 18th December, 1907.

Any person or persons may give notice of opposition to the amendment (on Form G), at the Patent-office, 25, Southampton-buildings, London, W.C., within one calendar month from the date of the said Journal.

C. N. DALTON,
Comptroller-General.

Haseltine, Lake and Co.,
Chartered Patent Agents,
P189 7 and 8, Southampton-buildings, London.

The British Liquid Air Company,

LIMITED, HEREBY GIVES NOTICE that it has been registered under the Companies Acts on the 18th of April, 1907, having for its object (*inter alia*) the Manufacture and Sale in Great Britain of LIQUID AIR, and also of OXYGEN and NITROGEN, obtained by RECTIFICATION, under the Patent Rights to which the said Company is entitled.

Dated this 2nd day of July, 1907.

For the BRITISH LIQUID AIR COMPANY, LTD.,
DAVID T. LARK,
Secretary,
934 14, Old Jewry-chambers, London, E.C.

King's College, London (University of London).

FACULTY OF ENGINEERING AND APPLIED SCIENCE.

NEXT TERM COMMENCES WEDNESDAY, JANUARY 8TH, 1908.

Professors:

Engineering	DAVID S. CAPPER, M.A., M.Inst.C.E., M.I.M.E.
	H. M. WAYNFORTH, A.M.Inst. C.E., A.M.I.M.E.
	M. CURRY, M.I.E.E.
Electrical Engineering	E. WILSON, M.I.E.E.
Natural Philosophy	H. A. WILSON, M.A., D.Sc.
	W. WILSON, Ph.D.
	H. S. ALLEN, M.A., B.Sc.
	J. NICOL, B.A., B.Sc.
Building Construction	R. ELSEY SMITH, A.R.I.B.A.
Chemistry	J. M. THOMSON, F.R.S., F.I.C.
Mathematics	S. A. F. WHITE, M.A.
	J. B. DALE, M.A.
Metallurgy	A. K. HUNTINGTON, A.R.S.M., M.I.M.E.
Geology and Mineralogy	H. G. SEELEY F.R.S.

EVENING CLASSES

are held for Civil, Mechanical, and Electrical Engineering, Workshop Practice, Architecture and Building Construction, Drawing, Mathematics, Physics, and other Science Subjects.

For Prospectuses and all information apply to the Secretary, King's College, Strand, W.C.

WALTER SMITH,
Secretary.
912

Bombay, Baroda, and Central

INDIA RAILWAY.

The Directors are prepared to receive, up to noon on Tuesday, 14th January, TENDERS for the SUPPLY of the following STORES, viz.:—

CLASS A.

1. Chemically-dressed Wagon Covers.
2. Metals.

CLASS B.

1. White Lead.

Tenders must be made on forms, copies of which, with specifications, can be obtained on and after the 30th inst. at these offices on payment as follows:—

For Class A 2s. each, and for Class B 10s 6d. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

W. V. CONSTABLE,
Secretary.

Offices, Gloucester House,
3, 3, and 4, Bishopsgate-street Without,
London, E.C.,
23rd December, 1907. 938

East Indian Railway.—The East

Indian Railway Company is prepared to receive TENDERS for the SUPPLY and DELIVERY of:—

LOCOMOTIVE ENGINES and TENDERS,

as per specification to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Engines and Tenders," not later than Twelve o'clock noon on Wednesday, the 22nd day of January proximo.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.

For each specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By order,
C. W. YOUNG,
Secretary.

Nicholas-lane, London, E.C.,
23rd December, 1907. 939

TENDER FOR FLOATING CRANE.

Quebec Harbour Commissioners

of Quebec, Canada, will receive TENDERS up to the 1st of May next for the SUPPLY of a THIRTY (30) TON CAPACITY FLOATING CRANE, particulars of which may be had from the Commissioners on application. The Commissioners do not bind themselves to accept the

ST. GEO. BOSWELL,
Chief Engineer.
824

Borough of Southend-on-Sea.

TO BUILDERS AND CONTRACTORS.

The Corporation invite TENDERS for the CONSTRUCTION of an UPPER DECK, SHELTERS, and other IMPROVEMENTS at the Pier Head, Southend.

Plans, specifications, and conditions may be seen, and bills of quantities and forms of Tender obtained on and after the 1st January, 1908 (on deposit of £1 1s., which will be returned on receipt of a bonâ fide Tender and the return of all documents) upon application to Mr. E. J. Elford, M.I.M.E., Borough Engineer, Southend-on-Sea.

Sealed Tenders, endorsed "Improvements, Pier Head," to be delivered at my office not later than 12 o'clock noon on Wednesday, the 15th January.

The Corporation will not be bound to accept the lowest or any Tender.

By order,
WILLIAM H. SNOW,
Town Clerk.

Town Clerk's Office,
Southend-on-Sea,
20th December, 1907. 925

The Bengal and North-Western

RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY and DELIVERY of:—

15,456 INCANDESCENT LAMPS,

as per specification to be seen at the Company's offices, on and after 30th inst.

Tenders, addressed to the undersigned, and marked "Tenders for Incandescent Lamps," are to be lodged not later than noon on Monday, the 13th day of January, 1908.

For each specification a fee of 10s. will be charged, which cannot under any circumstances be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By order of the Board,
ALEXANDER IZAT,
Managing Director.

27, Gresham House,
Old Broad-street, London, E.C.,
24th December, 1907. 910

The Rural District Council of

DARTFORD.

TO CONTRACTORS FOR SEWERAGE WORKS, &c.

The Rural District Council of Dartford invite TENDERS for the CONSTRUCTION of SEWERS in the Parishes of Eynsford, Farningham, and Sutton-at-Hone, of length in all about 11 miles, with the Manholes and other works in connection therewith.

Drawings and specifications may be inspected on or after the 27th inst. at the office of the Engineer, Mr. T. Hennell, Parliament Mansions Victoria-street, Westminster; and quantities and forms of Tender may be obtained at the same place on payment of a sum of Three Guineas, which sum will be returned to all parties who send in bonâ fide Tenders.

Tenders must be on the forms provided, and must be sealed and endorsed "Tender for Sewerage Works," and forwarded to the undersigned not later than Saturday, the 18th January, 1908, at 12 o'clock noon.

The Council do not bind themselves to accept the lowest or any Tender.

By order,
J. C. HAYWARD,
Clerk.

Sessions House,
Dartford,
16th December, 1907. 913

Wanted, a Competent Heating

ENGINEER as MANAGER for BRANCH OFFICE; good references indispensable.—Send full particulars of experience, addressed to 853, Engineer Office, 33, Norfolk-street, Strand W.C. 933

Wanted a Young Man, about

18 years of age, for Estimating Dept. in Mill Engineering and Millwrighting Works; must have had previous experience.—Address, 919, Engineer Office, 33, Norfolk-street, Strand, W.C. 919

Wanted at a Large Colliery in

North Staffordshire, a thoroughly capable and practical ENGINEWRIGHT; must be a 6 o'clock man.—Apply, giving age, experience, and salary required, with two recent references, to Box S, Hughes and Harber, Ltd., Longton. 915

Wanted in London, Assistant

ENGINEER and CHIEF DRAUGHTSMAN, thoroughly competent to design and detail structural work for important installations of Hoisting and Conveying Plant. Fair general knowledge of machinery for same desirable. Must be capable of efficiently directing and controlling large drawing-office staff. Salary about £300 per annum.—State age, particulars of experience, and when free, to 915, Engineer Office, 33, Norfolk-street, Strand, W.C. 915

Wanted, Manager for Motor

Works; must be an experienced man, used to the control of labour.—Replies (which will be treated in confidence) should be addressed, in first instance, to MOTOR, c.o. Walter Bates, 79½, Gracechurch-street, London, E.C. 908

Wanted, Works Manager for

Acid Siemens Steel Works, with hammering, cogging, and rolling mills; must be a really good administrator and organiser of men, and accustomed to high-class work and minute details. State age, salary required, and full experience and references. None but those thoroughly competent need apply.—Address, 871, Engineer Office, 33, Norfolk-street, Strand, W.C. 871

Wellsinker Wanted, a

thoroughly experienced Man, to proceed to South America to Superintend the Sinking of a Large Well; engagement for one or two years.

State age, experience, and salary required, to WELL, care Abbott, 32 Eastcheap, E.C. P188

Works Manager Wanted for Old-

established high-class Motor Works.—Apply, in writing, enclosing references and summary of last experience, to firm's solicitors:—WORKS MANAGER, Pinsent and Co., Bennett's hill, Birmingham. 944

Chartered Patent Agent Re-

QUIRES a TECHNICAL ASSISTANT to PREPARE MECHANICAL and ELECTRICAL SPECIFICATIONS; acquainted with Patent-office practice; preferably having passed Institute examination; not a draughtsman.—Address, P167, Engineer Office, 33, Norfolk-street, Strand, W.C. P167

Foundry Manager Wanted.—

FOREMAN to take Entire Charge of about 60 men in Ironfoundry, for Engine Works; must be good organiser, accustomed to control of men, mixing of metals, and plate moulding; non-society; salary expected, &c.—Address, 918, Engineer Office, 33, Norfolk-street, Strand, W.C. 918

The South Durham Steel and

Iron Company, Limited, REQUIRE the SERVICES of a thoroughly capable and energetic ASSISTANT to the Managing Director; one with technical knowledge.

Applications marked "Private" (which will be treated as confidential), stating age, experience, and salary expected, to be addressed to the SECRETARY, South Durham Steel and Iron Company, Limited, Stockton-on-Tees. 941

Appointments.—Intelligent Men,

over 21, not satisfied with their present prospects, who want PERMANENT POSITIONS, salaries £100 to £300 a year, should write for particulars of Inspectorships to INSPECTOR of WEIGHTS and MEASURES, Oakham, Rutland. 3045

Draughtsman Wanted; Experi-

ENCED in design of heavy Steam Automobiles; applicants to state age, experience, and salary required.—Address, P180, Engineer Office, 33, Norfolk-street, Strand, W.C. P180

Draughtsman Wanted, for Essex

Firm, used to Agricultural Implements and Food-preparing Machines; state qualifications, age, and salary required.—Address, 921, Engineer Office, 33, Norfolk street, Strand, W.C. 921

Smart Man Required as Shop

DRAUGHTSMAN or MANAGER'S ASSISTANT at London engineering works experienced in best modern shop methods and machinery. State age, experience, salary expected.—Address, 943, Engineer Office, 33, Norfolk-street, Strand, W.C. 943

Wanted Immediately, First-class

TOOL-ROOM FOREMAN for Motor Car Works in the Midlands. Only those who have held similar position need apply.—Address, 923, Engineer Office, 33, Norfolk-street, Strand, W.C. 923

Wanted, Shop Foreman over

Fitters, Turners, Smiths and Patternmakers; state age and experience; only well-trained and competent men will be considered; wages £3 per week.—THOMAS JOHNSON, Prescott-street, Wigan. 935

Shop Foreman or Assistant

WANTED by first-class mechanic; English and American experience; can produce results at minimum cost.—Address, P183, Engineer Office, 33, Norfolk-street, Strand, W.C. P183

Wanted Immediately by Large

Engineering Firm in Germany for their English Department, JUNIOR CLERK (Englishman), technically educated, able to translate from German into English; good opportunity to improve German.—Address, 946, Engineer Office, 33, Norfolk-street, Strand, W.C. 946

Foreign Traveller.—Clayton and

Shuttleworth, Limited, are DESIROUS of ENGAGING the SERVICES of a thoroughly competent and experienced TRAVELLER for their foreign trade. Preference will be given to one already having a connection and accustomed to receive orders for Steam Engines and Threshing Machinery.—Apply by letter only, giving full particulars of qualifications, and stating salary required, to S. S., c.o. Clayton and Shuttleworth, Limited, Lincoln. 922

Wanted, Chargeman Tool Fitter,

accustomed to Machine Tools, Erectors', Boilersmiths', and Smiths' Tools; age 35 to 45, about. Inexperienced applicants not required.—Address, 880, Engineer Office, 33, Norfolk-street, Strand, W.C. 880

Engineer Seeks Position as Fore-

MAN of WORKS or CONTRACT; age 32; strict disciplinarian and controller of men; experienced in deep well drilling, internal combustion engines, power gas plant construction, gas and steam installations, &c; first-class testimonials.—Address, 947, Engineer Office, 33, Norfolk-street, Strand, W.C. 947

Engineer, 23 Years' Experience

on the Clyde and in United States, with responsibility for WORKS ORGANISATION and COMMERCIAL MANAGEMENT of

SHIPBUILDING AND ENGINEERING UNDERTAKINGS,

of the first rank, including production of Marine and Stationary Engines, Boilers, and Auxiliary Machinery. Admiralty and Mercantile, new or repair, wishes to negotiate for appointment as

SUPERINTENDING MARINE ENGINEER OR WORKS MANAGER,

where his varied knowledge of Docking and all classes Hull, Engine, and Boiler Repairs, with Estimating and cost of same, Classification, Surveys, Upkeep and Maintenance of Steamships would be serviceable.

Address, 948, Engineer Office, 33, Norfolk-street, Strand, W.C. 948

Resident Engineer on Tropical

Railway will SHORTLY be AT LIBERTY. Good linguist.—Address, P171, Engineer Office, 33, Norfolk-street, Strand, W.C. P171

A.M.I.C.E. and Stud. I.C.E.

EXAMS.—CORRESPONDENCE COACHING by Practical Civil Engineers. Courses for any period. Fees moderate. Only one non-success last 5 exams. Special features for foreign candidates. Send for booklet, &c.—Address, P137, Engineer Office, 33, Norfolk-street, Strand, W.C. P137

Inst. C.E. and all Engineering

EXAMINATIONS.—Mr. G. P. KNOWLES, A.M.I.C.E., F.S.I., &c., PREPARES CANDIDATES Personally or by Correspondence. Many successes.—39, Victoria-street, Westminster, S.W. Tel. No. 1402 Victoria. 45

STRUCTURAL STEELWORK.

CORRESPONDENCE TUITION.

Thorough Tuition in BRIDGEWORK of all types, ROOFS of all descriptions, BUILDINGS on the American and Continental plan, &c. Send for Descriptive Booklet E (4th Edition), free on request. 583

MIDLAND ENGINEERING BUREAU, STRAND, DERBY.

To Engineers Going Abroad and

OTHERS.—Exceptional opportunity to ACQUIRE PRACTICAL INSTRUCTION in SURVEYING, LEVELLING, &c., on varied and extensive Surveys.—Address, P76, Engineer Office, 33, Norfolk-street, Strand, W.C. P76

A Well-known Firm of Locomo-

TIVE BUILDERS have VACANCIES for TWO ARTICLED PUPILS.—Address, 867, Engineer Office, 33, Norfolk-street, Strand, W.C. 867

Articled Pupil.—A Large Firm

of Engineers in the Midlands, employing upwards of one thousand hands, have a VACANCY for a PREMIUM APPRENTICE.—Address, 2003, Engineer Office, 33, Norfolk-street, Strand, W.C. 2003

Engineering Pupil.—A Firm of

Engineers in the West of England have a VACANCY for a PREMIUM PUPIL.—Address, 2001, Engineer Office, 33, Norfolk-street, Strand, W.C. 2001

Engineering Pupil.—Firm

(Government Contractors), employing 500 hands, have VACANCY; varied classes of work done, affording excellent opportunities; premium moderate.—Address, 2000 Engineer Office, 33, Norfolk-street, Strand, W.C. 2000

Engineers and Merchants, having

occasional inquiries from the North of England, but not sufficient business in the district for a regular agent, are INVITED to CORRESPOND with the ADVERTISER, a practical Engineer and an A.M.I. Mech. E., established on the N.E. Coast, who would be pleased to follow up these inquiries or give other assistance at reasonable terms.—Write, 823, Engineer Office, 33, Norfolk-street, Strand, W.C. 823

Industrious Firm in Paris is Look-

ING OUT for the SOLE AGENCY of all kinds of Isolating Materials, Tools, and Machinery for Tools.

Apply to—
P. METIVIER & CIE., 94, Rue de la Victoire. P189

ENGINEERING FIRMS
of good standing with

OPENINGS FOR PARTNERS, or BUSINESSES FOR SALE,

are requested to communicate with

WHEATLEY KIRK, PRICE & CO.,
46, Watling St., London, E.C.;
16, Albert Square, Manchester;
26, Collingwood St., Newcastle-on-Tyne. 3005

Wanted to Borrow, at 5 per cent.,

£4000 on Freehold Land and Buildings in the Midlands.—Apply, THOMAS DALTON, Esq., Solicitor, Southparade, Leeds. P169

All Inventors Requiring Capital

should WRITE or CALL CROZIER and CO., Ltd., Patent Experts, 110 and 111, Strand, London, who have many capitalists on their books who will buy good, simple inventions. No result no charge. Advice free. 1985

Gentleman, with 3 Years' Techni-

CAL Training and since Electric Traction and other experience, would like POSITION with ENGINEERING or other BUSINESS in London district. Might invest later.—Write, Z. K., 7.6, Messrs. Deacon's, Leadenhall-street, E.C. 927

£2000-£5000.—Engineer Re-

QUIRED as ACTIVE DIRECTOR in large Motor Garage and Manufacturing Works, London, with important and lucrative contracts.—Particulars from Messrs. ARNOLD and CO., 60, Queen Victoria-street, E.C. 931

£5000.—Engineer Required as

ACTIVE DIRECTOR in old-established engineering and Ironfounder's Business in the North, showing good profits, and open to closest investigation.—Particulars from Messrs. ARNOLD and CO., 60, Queen Victoria-street, E.C. 930

Wanted, a Good Second-hand or

NEW SLOT DRILLING MACHINE, suitable for both light and heavy work.—H. J. R. KING and CO., Engineers, Nailsworth. 916

Wanted, Locomotive Weighing

MACHINE to weigh up to 40 Tons.—Apply, "MADEIRA," Porthcawl. 920

Wanted, One Lancashire Boiler,

about 30ft. long × 7ft. 6in. diameter, minimum working pressure 100 lb; must stand insurance inspection; urgent.—Address, 9.4, Engineer Office, 33, Norfolk-street, Strand, W.C. 914

Wanted, Punching and Shearing

MACHINE; also Single-ended PUNCH, 3in. metal, belt-driven; must be in good condition. State price and full particulars, delivery Bridgend, South Wales.—Address, 924, Engineer Office, 33, Norfolk-street, Strand, W.C. 924

Wanted, Short Gap Lathes, 7in.

to 10in. centres; also MILLING MACHINE, suitable for die making.—Address, 897, Engineer Office, 33, Norfolk-street, Strand, W.C. 897

Wanted, 60 to 70 K.W., 220

volt, continuous current direct-coupled COMPOUND STEAM GENERATOR; must be first-class condition.—Address full particulars to 942, Engineer Office, 33, Norfolk-street, Strand, W.C. 942

Gun-metal, Brass, or Aluminium

SCRAP PURCHASED.

Apply, HUNT and MITTON, Ozzells-street North, Birmingham. 585

BUYERS AND SELLERS

OF IMPORTANT SECOND-HAND

ELECTRIC LIGHTING & POWER PLANTS

in good running order are requested to communicate with

WHEATLEY KIRK, PRICE AND CO.,
46, WATLING-STREET LONDON, C. Spl 3004

A Big Stock of Surveying Instru-

MENTS, DRAWING INSTRUMENTS, Draughtsmen's MATERIALS, and PAPER in stock.

E. R. WATTS and SONS,
109, Victoria-street, S.W. (next door to Army and Navy Stores). 821

BUYERS AND SELLERS

FOR CASH

OF POWER AND OTHER PLANTS,

And Complete Works or Part,

FOR RE-USE OR DISMANTLING.

THOMAS MITCHELL AND SONS, LTD.,
BOLTON. 865

SMALL ADVERTISEMENTS

SITUATIONS FOR SALE, &c.

Pages II., III., LXVI.

Numerical Index to Advertisements
Page LXIII.

Subject-Matter Index to Advertisements
Page LXV.

Electric Light Plant—9 H.P

Crossley High-speed Engine, Castle Dynamo for 90 lights, Switchboard, everything complete; cheap.—WATSON 4, High-street, Maidstone. P185

For Hire, Pumps and Well

BORING TOOLS for Contractors, Deep Wells, &c., 2in. to 24in. diam.—R. RICHARDS and CO., Upper Ground-street London, S.E. Telephone No. 978 Hop. S22

For Sale :—

GAS ENGINES, Second-hand, 7, 10, 13, and 18 brake H.P condition. Bargains. Write for list.

NEW GAS ENGINES, all sizes, 1½ to 700 H.P.

PUMPING ENGINES, of Compound Duplex type, Second-hand, 30,000 gallons per hour capacity.

FIELDING AND PLATT, LIMITED,
GLOUCESTER. Y344

For Sale :—

Nearly new Iron BAND SAW (by Clifton and Waddle), to admit 7ft. diam.

Four Roots BLOWERS coupled to vertical engines, 10in. cyls., 9in. stroke, outlet 14in. diam.

No. 3 Fowler's PIPE BENDING MACHINE.

REELING MACHINE, to take bars up to 6in. diam.

SCARFING MACHINE (by Geo. Richards, of Broadheath).

Plate Edge PLANING MACHINE, open type, 17ft. 6in. between standards.

Double-ended Cameron type PUNCHING and SHEARING MACHINE, with angle cutters, take 11in. by 11in.

Double-ended Steam-driven Cross-cut SHEARS (by Buckton and Co.), to cut 22in. by 1¼in. hot.

4 cwt. Power-driven HAMMER.

Steel BARREL-MAKING PLANT, nearly new.

Powerful full Universal Radial DRILLING MACHINE, 4in. spindle, 10ft. 3in. arms.

Back-driven PLANING MACHINE, to plane 10ft. by 3ft. by 3ft.

Lathes, Planers, Shapers, Slotters, Drilling Machines, various sizes. Descriptive catalogue of 2000 lots free on application.

Machinery let out on hire or sold on purchase hire. Inspection invited.

THOS. W. WARD, LIMITED,
ALBION WORKS, SHEFFIELD. Spl.4101
Telegraphic address: "Forward, Sheffield.

DISMANTLING OF THE DEARNE AND DOVE STEEL WORKS, WORSBORO' DALE, NEAR BARNSLEY.

For Sale :—

2-Ton Robert BESSEMER CONVERTER.

Horizontal Tandem BLOWING ENGINE, 24in. steam cyl., 28in. blowing cyl., 3ft 6in. stroke.

10-Ton Overhead Steam TRAVELLING CRANE, 45ft. span.

Two 2-Ton HYDRAULIC CRANES.

Nearly New No. 4 ROOTS BLOWER, with Vertical Engine, by Thwaites Br. &

One No. 25 size BAKER BLOWER, with Vertical Engine.

CUPOLA, 32ft. by 5ft. 6in.

CUPOLA, 32ft. by 4ft.

STOVE CARRIAGES, LADLES, &c.

For further particulars or to inspect apply,

THOS. W. WARD, LIMITED,
ALBION WORKS, SHEFFIELD.
Telegraphic Address: "Forward, Sheffield."
Telephones: 188, 1472, 2892, and 2921. 895

For Sale :—

12in. by 18in. 4-wheels coupled
SADDLE-TANK LOCOMOTIVE,

all re-built with new boiler, &c., and equal to new.
THE AVONSIDE ENGINE COMPANY,
Bristol. Y949

For Sale, Diving Apparatus,

complete, in thorough working condition, Henkie's pattern, three-throw pump.—Address, W. M., 25, Peninsula-road, Tilbury. P136

For Sale, Great Bargains :—

HORIZONTAL TANDEM TWO-CYL. COMPOUND SURFACE-CONDENSING ENGINE, by Pollitt and Wigzell, cyls. 16½in. and 28½in. dia., 4ft. stroke.

Also magnificent COMPOUND HORIZONTAL ENGINE, cylinders 13½in. and 24in. by 24in. stroke, 12ft. fly-wheel grooved for eight ropes 1¼in. diameter, fitted with high-pressure piston valve and expansion valve.

STEAM CRANES, from 30 cwt. up to 5 tons, by best makers.

CHARLES D. PHILLIPS, Emlyn Engineering Works, Newport, Mon. (and Gloucester). Est. 40 years. 934

For Sale, New High-class Planing

MACHINE, to plane 6ft. by 2ft. 9in. by 2ft. 6in., machine-cut gear, &c.—I. COHEN and CO., 240, Blackfriars-road, London, S.E. 598

For Sale, New Steel Steam

HOPPER BARGE; hopper capacity, 17,000 cubic feet; speed, loaded with 850 tons spoil, about 8 knots; classed at Bureau Veritas.—For further particulars apply to 2047, Engineer Office, 33, Norfolk-street, Strand, W.C. 2047

For Sale, New Steel Lancashire

BOILERS, ready for immediate delivery :—

30ft. × 7ft., for 100 lb. working pressure.

30ft. × 8ft., for 100 lb., 130 lb., 150 lb., and 180 lb. w.p.

30ft. × 8ft. 6in., for 100 lb., 120 lb., 140 lb., and 160 lb. w.p.

Other sizes in progress.

SPURR, INMAN AND CO., LIMITED,
Calder Vale Boiler Works, Wakefield. X1870

For Sale, One 6¾in. by 30in. Deep

WELL PUMP, complete with suction, 150ft. rising main, rods and gearing.

Ditto, 7½in. × 24in., for 170ft. lift, with gearing and motor complete.

One STEAM WELL HEAD, by Blake Knowles, 12in. cyl. 24in. stroke.

For SALE or HIRE, Direct-acting STEAM and AIR LIFT PUMPING PLANTS, new and second-hand, any capacity or lift.

A. C. POTTER AND CO., Spl3001
Lant-street, Borough, London.

For Sale or Hire :—

PORTABLE ENGINES, 6 to 30 N.H.P.
SEMI-PORTABLE ENGINES, 12 to 50 N.H.P.
TRACTION ENGINES, 5 to 10 N.H.P.
PLOUGHING ENGINES and Implements.
CENTRIFUGAL PUMPS.
SAW BENCHES and SAWS.

Immediate delivery from works for breakdowns, &c

HENRY LEWIS AND SONS,
ENGINEERS, READING. Y712
Telegrams "Lewis, Reading." Full list free.

For Sale, Powerful Vertical Drilling

MACHINE, admits 36 dia., on tee-slotted compound table, spindle 2½in. dia.; all self-contained; in good condition.—I. COHEN and CO., 240, Blackfriars-road, London, S.E. 757

For Sale, Quite New, Lancashire

BOILER, 30ft. × 7ft. × 96 lb. working pres.; CORNISH BOILER, 13ft. × 6ft. × 110 lb. working pres.; LOCOMOTIVE BOILER, 14 N.H.P., 110 lb. working pres.; also HORIZONTAL STEAM ENGINE, 16in. × 30in., bent crank, turned fly-wheel.

For particulars and prices, apply, H. COLTMAN and SONS, Boilermakers, Loughborough. 3036

For Sale, Side-planing Machine,

Richard's patent, to plane 5ft. by 12in., two tables; in first-class condition.—I. COHEN and CO., 240, Blackfriars-road, London, S.E. 756

The WELDLESS STEEL TUBE Co., Ld., Birmingham
Telegrams: "Weldless, Birmingham."
Original makers of WELDLESS STEEL TUBES for Water Tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
TRADE WELDLESS MARK. 4167

A. G. MUMFORD, LD.

CULVER STREET ENGINEERING WORKS,
COLCHESTER.

CONTRACTORS TO ADMIRALTY, WAR-OFFICE, CROWN AGENTS FOR THE COLONIES, AND FOREIGN GOVERNMENTS.

STANDARD PATTERNS LAUNCH and MARINE ENGINES in stock and in progress.
COMPOUND SURFACE CONDENSING :—

Cylinders								
in.		in.		in.				
3½	and	5	diameter	×	4	strokes,	Admiralty	pattern
5	"	6	"	×	5	"	"	"
5½	"	7½	"	×	6	"	"	"
6½	"	9	"	×	6	"	"	"
5	"	10	"	×	6	"	"	"
6	"	12	"	×	7	"	"	"
7	"	14	"	×	8	"		
8	"	16	"	×	10	"		
9	"	18	"	×	12	"		
10	"	20	"	×	14	"		
11	"	22		×	16	"		
12	"	24		×	16	"		
14	"	26	"	×	18	"		

New designs and highest class workmanship. Sp4178
Catalogue and full particulars on application

PRIESTMAN OIL ENGINE

FOR SALE,

With Shaft, Stern Tube, and Propeller.

QUITE NEW. 9 B.H.P.

Suitable for Launch 40ft. long.

Will be SOLD AT A SACRIFICE to close an account.

For particulars, apply to—

ALEX. WILSON (Spl) 4237
3, LOMBARD COURT, E.C.

HARPERS' LIST.

PAGES XIV.—XV.
THREE WEEKS AGO.

REELED STEEL BARS

For Turret Lathes and Automatics,

THEY ARE { CHEAP. STRAIGHT, FREE FROM SCALE.

THEY CAN BE OF ANY REQUIRED GRADE OF MATERIAL.

Also

BRIGHT DRAWN STEEL BARS

IN STOCK.

ALFRED HERBERT, Ltd.,
COVENTRY. 4000

CHARLES LANCASTER.

TO H.M. THE KING.

Est. 1826.

£63, £45, £35, £26, and £22.

THE ART OF SHOOTING." Seventh and Revised Popular Edition, 2/6; postage 6d. extra.

"THE NORTH-WESTERN SHOOTING SCHOOL." Z263a

11, PANTON STREET, HAYMARKET, LONDON, S.W. (Opposite Comedy Theatre.)

J. SHEWELL & CO.

Steel and Iron Bridge Builders.

PRESSED STEEL { TROUGH FLOORING SHEET PILES CUTTERS (Spl) 4284

Works: DARLINGTON.

POTT, CASSELS & WILLIAMSON,

MOTHERWELL.

SEE HALF PAGE ADVERTISEMENT
THREE WEEKS AGO. Q428

COTTON-ROPE PULLEYS

up to 18ft. Diameter.

FRICTION CLUTCHES, PLUMMER BLOCKS, SHAFTING, SPUR WHEELS.

THOMPSON and SOUTHWICK, Ltd., TAMWORTH.

See illustrated advert. last and next week. Q362

Farnley Iron.

Best Yorkshire)

The Toughest and Best in the World.
Easiest to Smith.
Safest to Weld.

The Farnley Iron Co., Ltd., Leeds.

CRAVENS LIMITED,

RAILWAY CARRIAGE AND WAGON WORKS,
DARNALL, NEAR SHEFFIELD.

Manufacturers of

Description of RAILWAY CARRIAGES, WAGONS TRAMCARS, IRONWORK, WHEELS, and AXLES, BRASS and IRON CASTINGS, &c.

Wagons Built for Cash or for Deferred Payments. Prices and Specifications on Application. 487

THE GLASGOW RAILWAY ENGINEERING COMPANY,

GOVAN, GLASGOW. LTD.

London Office:—12, VICTORIA STREET, S.W.

MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES, CARRIAGE AND WAGON IRONWORK also CAST STEEL AXLE BOXES. Q402

RAILWAY & TRAMWAY SPRINGS

to British, Colonial, India-Office Specifications, &c.

Wm. GRIFFITH & SONS, Ltd.,
Sheffield.

Napier Steel and Spring Works and Providence Works.
London Offices—
Foothill 86, 4, 5 & 6, Queen Anne's Chambers, Westminster, S.W.
Telegraphic Address—Griffith, Sheffield.
National Telephone No. 985. 925

ESTABLISHED 1861.

HARRISON & CAMM, Ld.

Chief Works and Offices—ROTHERHAM.

Manufacturers of

WHEELS & AXLES

With Cast or Hydraulic Forged Naves.

Wagon Ironwork, Castings, RAILWAY WAGONS (in Iron, Steel, or Timber). 491

LOCOMOTIVES IN STOCK.

KERR, STUART & CO., LTD.,

Have in stock, or in an advanced state of progress, at their California Works, Stoke-on-Trent, a large number of

LOCOMOTIVES,

With cylinders from 5in. to 13in. diameter (inclusive), for all gauges from 18in. to 4ft. 8½in.—Apply to KERR, STUART and CO., Ltd., 1, Broad St. Place, E.C. 998

P. & W. MACLELLAN, LTD.

CLUTHA WORKS, GLASGOW.

Manufacturers of RAILWAY WAGONS and CARRIAGES IRON and STEEL SLEEPERS, FISH BOLTS, SPIKES, and other PERMANENT WAY MATERIAL, BRIDGES, and ROOFING.

CONTRACTORS for RAILWAY PLANT and STORES of every description.

Chief Offices—129, Trongate, Glasgow. 861
Registered Offices—108a, Cannon-street, London, E.C.

MIDLAND

RAILWAY CARRIAGE & WAGON CO.,
LIMITED,
MIDLAND WORKS, BIRMINGHAM
AND
ABBEY WORKS, SHREWSBURY

RAILWAY CARRIAGES,
RAILWAY WAGONS,
TRAM CARS, &c. &c.

LONDON OFFICES— 482
SUFFOLK HOUSE, LAURENCE POUNTNEY HILL E.C.

R.Y. PICKERING & CO., LTD.

(Established 1864).

Builders of Railway Carriages and Wagons.
Makers of Wheels and Axles of all kinds.

Chief Works and Offices—
WISHAW, NEAR GLASGOW.
London Office— RC505
3, VICTORIA STREET, WESTMINSTER, S.W.

The Trustees for the Debenture Holders of

W. R. RENSHAW & CO.,

Phœnix Works, Stoke-on-Trent. LTD

Rolling Stock

of every description for Home and Foreign Railways.
See Illustrated Advt. last & next week. RC504

G. R. TURNER, LD.

Manufacturers of all descriptions of
IRON & WOOD FRAME WAGONS
For Home, Colonial & Foreign Railways.
WHEELS & AXLES.
PERMANENT WAY MATERIALS, &c.
Colliery Screening and Conveying Plants, Engines, Tipplers, Elevators, Structural Work, Roofing, Castings of all descriptions.
Chief Works & Offices: LANGLEY MILL, nr. NOTTINGHAM
London Office: Sanctuary House, Westminster.
See Illustrated advt. first issue in each month on page 8.

BERTRAMS LIMITED

Engineers, SCIENNES,
EDINBURGH.

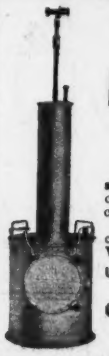
See our Illustrated Advertisement of
SPECIAL CENTRIFUGAL PUMPS
In ENGINEER first issue of each month. Sp1421

The BUTTERLEY COMPANY, Ltd.

DERBY.

SPECIAL WELDING STEEL. (Spl) 2 A1661a

See Illustrated Advertisement last week's ENGINEER Page 19.



WAKEFIELD'S PATENT

ACETYLENE FLARE LIGHTS & HAND LAMPS.

Each Flare Light is fitted with adjustable burner, giving any power up to 2000 candles. In two sizes: 6-hr. and 12 hr. capacity.

The Hand Lamp gives a light of 100 c.p. for 10 hours, with one charge. Weight, fully charged, 18 lbs.

Used by 100 Railways and Principal Contractors.

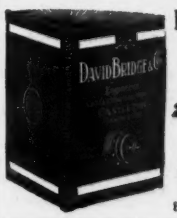
C. C. WAKEFIELD & CO.
27, Cannon St.,
4157 LONDON, E.C.

DERMATINE CONDENSER PUMP VALVES.

Manufactured only by—

DERMATINE CO., Ltd., 95, Neate St., London, S.E.
Tel. Address, "Dermatine, London." Tel. No. Hop 81.
Dermatine is also made in the form of Belting, Hose, Hydraulic Rings, Pump Cups, &c. (Spl) 4235

HEYWOOD & BRIDGE'S PATENT



FRICTION CLUTCHES,

GEARING & HAULING PLANTS.

200 Page Work (Spl) 4233
FREE.

DAVID BRIDGE & CO.,
Castleton, Manchester.
Please mention "The Engineer

HIGH SPEED DRILLING.

Radial, Vertical, and Horizontal Machines.
WM. ASQUITH, Ld., High Road Wells, HALIFAX.
See advertisement December 13th. Q462

LATHES

for Heavy Cutting at High Speeds.

J. & P. HILL, SHEFFIELD

See Illustrated Advert. last and next week. Q548

JENS ORTEN-BØVING,

72, Victoria Street, WESTMINSTER, S.W.
Sole Representative for - -
ESCHER, WYSS & CO., LD.
SPECIALITIES—
WATER TURBINES, STEAM TURBINES, CENTRIFUGAL PUMPS, &c. S229
See Illustrated Advertisement each month.

AUTO. RECORDERS.

Weighing Coal, Ores, Cement, or anything else.

THE BLAKE-DENISON,
PARKSIDE, LEEDS, S.E. D27

GRAIN, CHILL & STEEL ROLLS.
HEAVY CASTINGS Iron up to 100 tons. Steel up to 40 tons.
Cast Steel Loco. Wheel Centres a Speciality.
R. B. TENNENT, LIMITED,
HM49 COATBRIDGE, N.B.

VALVES

AND

PATENT SAFETY BOILER MOUNTINGS

SPECIFY Q60

'J. HOPKINSON & CO., Ltd., Huddersfield."

DRUMMOND BROS., LD.

Small High-Class

LATHES

RYDE'S HILL, near GUILDFORD

See advertisement last and next week. Q548

STEEL LINK-BELTS

CONVEYORS & ELEVATORS.

GILBERT LITTLE COV., LTD.,

HORTON WORKS, BRADFORD.

PHOENIX Patent CONNECTIONS and WOOD-FRAMING SYSTEM

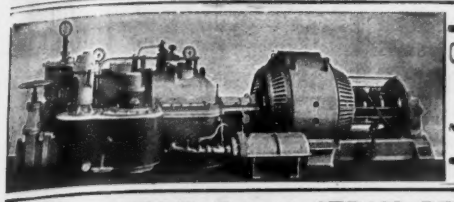
Are the cheapest and most Durable for Industrial and Agricultural Sheds, Pavilions, Bungalows, Railway, and Exhibition Buildings, Telegraph Poles and Supports, &c.

Write for full Particulars and Estimates to— Telegrams—OVERARCHED, LONDON.

MURRAY LOTZ & CO., 102, Fenchurch St., London, E.C.

British Representatives of C. W. HUNT and CO., New York, and J. POHLIG, Cologne. D10

First-class Patent Factory Railways, Electric Storage Battery Locomotives, Hoists, Elevators, Conveyors, & every description of Transporting Machinery.



C. A. PARSONS & Co.'s EXHAUST STEAM TURBINES

Newcastle-on-Tyne, London, Leeds, Glasgow, & Cardiff.

AULD'S Patent STEAM REDUCING VALVES.
AULD'S Patent SURPLUS STEAM VALVES.
Patent FULL-BORE STEAM REDUCING VALVES.

DAVID AULD & SONS, Patentees & Makers

Telegrams—REDUCING, GLASGOW. Whitevale Foundry, GLASGOW.

South African Agents—Messrs. DAVID C. BOYD & CO., Post Office, Box 2259. Address, Silesia Buildings, opposite Winchester House, Main Street, Johannesburg. Q351

Water Softeners

Perfect Boilers

are kept in perfect order by feeding them with soft and pure water, such as is ensured by the installation of a Lassen and Hjort Patent Automatic Water Softener.

Spl 420

— All Plants made in London works. —

Lassen & Hjort
Engineers
52 Queen Victoria St London E C

Established 1867. T.A.—BEELEY HYDE. T.N.—61, HYDE. Contractors to the British Government.

BOILERS

and Complete Steam Plants.

THOMAS BEELEY & SON, Ltd., Hyde, Nr. MANCHESTER. Special Steel & Iron Vessels of all classes.

See our large advertisement see page 5 of last and next week's issue. Q546

DANIELS' PATENT

GAS PLANTS

PRESSURE AND SUCTION.

Large Numbers working from **6 TO 600 B.H.P.**

T. H. & J. DANIELS, Ltd., STROUD, GLOS., E56

London Office—22, Henrietta Street, Strand, W.C. Teleg.—Rotapulim, London. 'Phone—9850 Central

Manchester Office—49, Deansgate. Teleg.—Booster, Manchester. 'Phone—341 Y Central

The NEW MECHANICAL

WOOD-WORKER

(Patent)

For ENGINEERS, SHIPYARDS,

PATTERN SHOPS, &c. T99

WADKIN & CO.,

North Evington Eng. Works, LEICESTER.

See Illus. Advt. every third week.

GEO. COOPER & SONS

(SHEFFIELD), LTD.,

MANUFACTURERS OF

Bolts and Nuts, Coach Screws, Spikes, Set Screws, Rivets, Washers, &c., for Railways, Wagon Builders and General Purposes.

EFFINGHAM NUT & BOLT WORKS, SHEFFIELD. Q574

THE

LODGE IGNITION.

See Advertisement page xxiii. Dec. 13.

THE LANARKSHIRE BOLT & RIVET CO.

(Pillans's), Burnbank, HAMILTON.

BOLTS & RIVETS of every description in IRON & STEEL.

SPECIAL QUOTATIONS FOR SHIPMENTS.

Telegraphic Address— "PILLANS, HAMILTON." Glasgow Office— 90, Mitchell Street. m31

HYDRAULIC RAMS,
WATER & STEAM TURBINES, PUMPS
"CHAMPION"
ROCK DRILLS & AIR COMPRESSORS.

Catalogues and Estimates free upon receipt of specification of requirements. Q538

H. P. VACHER, HYDRAULIC WORKS, WINCHESTER.

DROP FORGINGS & PRESSINGS IN IRON & STEEL

Of all descriptions. Enquiries Solicited.

HIRLEW BROS., Ltd.,

Nasmyth Works, 198, Blackstock Rd., LONDON, N

MECHANICAL, ELECTRICAL and TRAMWAY ENGINEERS.

Manufacturers of Engineering Specialities. Q576

Telegrams—COMMUTATOR, MANCHESTER. **GEORGE HILL & CO.,** Trafford Electric Works, Cornbrook, MANCHESTER. NATIONAL TELEPHONE—No. 2920.

EARLY DELIVERY.

In progress for delivery in one to two weeks One Cross Compound STEAM ENGINE, with cylinders 12in. and 21in dia. by 24in. stroke, for 140 lb. working pressure. Specification, Illustration, and Prices on application. Q598

See Illus. Advt. in issue of Dec. 20th.

F. BREARLEY Ltd.,

Central Ironworks, SHIPLEY, Yorks.

BLAKE PATENT BOILERS,

STEEL RAILWAY WAGONS,

RAILWAY WHEELS, BRIDGES, &c.

See Last and Next Week's Advts. Q549

BLAKE BOILER, WAGON & ENG. CO., Ld., DARLINGTON.

GREAT SAVING IN FUEL.

PATENT MACHINE FOR BREAKING and RIDDLING

GAS COKE for Smiths' Fires.
FOUNDRY COKE for Brass and Steel Works.
ANTHRACITE COAL for Suction Gas Plants.

Capacity 30 cwts. per hour. Adjustable Rollers to break size required. Space occupied, 3ft. 6in. × 3ft. 6in. × 4ft. 3in. high. Revs., 200. Power, ½ h.p.

AT WORK WITH THE FOLLOWING FIRMS:

Messrs.	RUSSELL & Co., Shipbuilders, Port Glasgow	2 Machines
,,	WM. HAMILTON & Co, Ltd., Shipbuilders, Port Glasgow	2
,,	CAMPBELTOWN SHIPBUILDING Co., Campbeltown	1
,,	BURGH OF HAMILTON, Gas Works	1 ,,
,,	LLOYD'S TESTING HOUSE, Cardiff	2 ,,
,,	SHERRATT & REAM, Ltd., Wheelwrights, Manchester ..	1 ,,
,,	THE BRITISH WESTINGHOUSE Co., Manchester	1 ,,
,,	ANNE COWBURN, Ltd., Coachbuilders, Manchester ..	1 ,,

AND NUMEROUS OTHERS. T3

T. & R. LEES, Engineers, **HOLLINWOOD,** near **MANCHESTER.**

THE KLEIN ENGINEERING CO., LTD

Specialists in { CONDENSING PLANTS. WATER-COOLING PLANTS. WEIGHING MACHINERY.

94, Market St., MANCHESTER. Q304

Telegrams—Modernize, Manchester. Telephone—No. 4070.

Patent Fuel and Briquette Plants

from 12 to 200 Tons per day.

WINDING AND HAULING ENGINES.
RAILWAY AND LOCO. WHEEL REPAIRS.
FUEL MANUFACTURERS: BLACKPLATE MILLS. D40

RICHARDS & THOMPSON, LTD.,

Works: CAERLEON and NEWPORT (Mon.)

W. P. BUTTERFIELD,

Galvanizing and Tank Works,

SHIPLEY, YORKS.

SEE MY ADVERT. LAST & NEXT WEEK. Q614

KORTING BROS., LTD., Telegrams—KORTING, LONDON. Telephone—49 VICTORIA.

53, Victoria St., WESTMINSTER.

CENTRIFUGAL PUMPS

60-70 per cent. Efficiency for Lifts from 10-66 feet.

SPECIAL CONDENSERS

FOR

STEAM TURBINES.

giving 28" Hg. vacuum without use of Air Pumps.

Condensers in all sizes from

10 to 10,000 H.P.

EJECTOR CONDENSERS.

SPRAY PLANTS

Cooling water to 75° Fahr. with pressure head of 17 feet.

AUTOMATIC EXHAUST VALVES

AND F66

BALANCED CHECK VALVES.

CORRUGATED

FURNACE BARS

For Land and Marine Boilers.

These Bars are made with the surface specially hardened, and cannot fuse or burn at the edges. The design of the Bar ensures air space, giving thorough consumption of fuel.

Furnace Bars with Special Chilled Face.
Double the Life of Ordinary Bars.

Manufacturers of
CHILLED IRON CASTINGS
for all purposes. sm53

MILLER & CO., LD.
London Road Foundry, EDINBURGH.

CHAINS.

WILLIAM DALE,
Ancoats Chain and Testing Works,
Mill St., Ancoats, Manchester

All kinds of WINDING-ON & BACKING-OFF CHAINS for Mules; also CHAINS for Looms, Cranes, Hoists, &c
TREBLE BEST QUALITY.
50 Tons of all Sizes kept in Stock. Q487
TESTS MADE & PROOF CERTIFICATES GIVEN
Telegrams—REPAIRS. Telephone—3090

ALEX. FINDLAY & CO., LTD.,
STEEL ROOF & BRIDGE BUILDERS, & STRUCTURAL ENGINEERS.
Specialty: HYDRAULIC PRESSED STEEL TROUGH FLOORING for Road & Railway Bridges, Buildings, &c
9, VICTORIA ST., LONDON, S.W. sm19
HEAD OFFICE—PARKNEUK WORKS, MOTHERWELL.

LOUISIANA RED CYPRESS.

THE IDEAL WOOD.

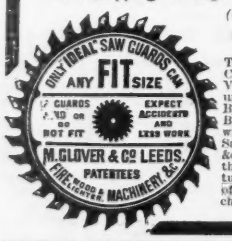
For Tanks, Vats, and Tubs of all kinds for Brewers, Distillers, Soap Manufacturers, Acid Manufacturers, and Dye Tanks for Woollen Mills, also for Paper Mill Tanks and Starch Makers' Tanks.

It imparts neither odor, taste, nor color to the contents, and it lasts almost for ever.

Free samples and other information mailed on request.

ROBERT C. IRWIN, European Agent,
Louisiana Red Cypress Co., 731
North-Western Hotel, LIVERPOOL.

SAWDUST
and Chippings Firelighter Machines
(Glover's Patents)
MAKE MONEY.


ONLY IDEAL SAW GUARDS CAN
ANY FIT SIZE
GUARDS 2/6 OR NOT FIT
EXPECT ACCIDENTS AND LESS WORK
M. GLOVER & Co LEEDS.
PATENTEES
FIRE LIGHTER MACHINERY &c

THE MOST SUCCESSFUL YET INVENTED. Cheap unique Mixture from By-Products. YOUR BUSINESS. Those who make or can buy Sawdust, Chippings, &c., should consider the advisability of turning it by means of this Patent Machinery, into money. Q540

Machinery Contracts.
London Office: 159, Queen Victoria St., E.C.
Supply all kinds of MACHINERY and PLANT on 'THE TIMES' SYSTEM of PAYMENT.
Extending to 1, 2, or 3 years. The business is simply an ordinary sales contract for which we charge 5 per cent. on Invoice Amount. We have supplied Machinery and Plant to the value of scores of thousands of pounds, and never had any complaint or cause to regret allowing long credit.
Write or call and state what Machinery or Plant you require. D45

S. A. DANIELL, LIMITED
SPECIALITIES:— BIRMINGHAM.
Lion Brand Copying Presses.
Screw Stocks, Dies and Taps.
Q446 Screwing Machines

Latest Award, Milan International Exhibition, 1906, British Section,
TWO GRAND PRIX.

WORTHINGTON
PUMP COMPANY, LIMITED,

Telephones: 314, 631 and 5097 Bank.
With which is Incorporated the European Business of HE BLAKE AND KNOWLES STEAM PUMP WORKS.
Registered Offices—
153, Queen Victoria Street, LONDON, E.C.
and Principal Towns and Cities throughout the World.
Telegrams & Cables Pumping, London Steampump, London

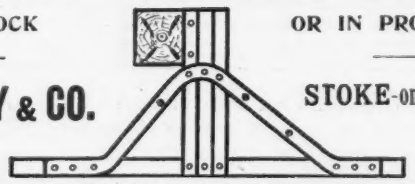
MANUFACTURERS OF HIGH-CLASS
Pumping Machinery
OF ALL TYPES AND FOR EVERY SERVICE.

AIR COMPRESSING MACHINERY
of every Description. Catalogue L 510.
CENTRIFUGAL PUMPS
To Work against all Heads. Highest Efficiencies Guaranteed. Catalogue No. 7.
TRIPLEX POWER PUMPS
In either Horizontal or Vertical Design. Catalogue D 30.
MARINE PUMPS
For Bilge, Ballast, Fire or Feed Service. Catalogue B E 106.
AUTOMATIC EXHAUST RELIEF VALVES.
Catalogue B E 87.
COOLING TOWERS
Natural or Forced Draught.
SURFACE CONDENSERS AND FEED WATER HEATERS
Of any Capacity. YM28

Every Engineer should be in Possession of our
SPECIAL Illustrated GENERAL CATALOGUE.

RAILWAY BUFFER STOPS

IN STOCK OR IN PROGRESS.



HARTLEY & CO. STOKE-on-TRENT
D36
STRUCTURAL ENGINEERS. —o— IRON ROOFS, ANY SPAN.

THOMAS CHATWIN,
"Victoria Works," Great Tindal Street,
BIRMINGHAM.
Manufacturer of
ENGINEERS' SMALL TOOLS.

BANNISTER'S PATENT
INSERTED TOOTH
MILLING CUTTER
WITH HIGH SPEED OR CAST STEEL TEETH.
Send for List. X1092

Feed Water Heaters.
ALL KINDS FOR EXHAUST & LIVE STEAM
POLLOCK, MACNAB & HIGHGATE,
H315 Shettleston, GLASGOW.

FOR PHOTO PRINTS & PAPERS
and all
DRAWING OFFICE SUPPLIES,
B. J. HALL & CO., Ltd.,
39, Victoria Street, London, S.W. Z227
SEE OUR ADVERTISEMENT, DECEMBER 13th.

PLAYER'S POWER HAMMERS.

Z75a
W. & J. PLAYER, BIRMINGHAM

SUCKLING'S
WATER-TUBE BOILER.
PATENTED
Reliable. Durable. Economical. Accessible.
High-class Boiler at moderate cost. Suitable for export. Specially adapted for Electric Light & Power Stations.
Apply to:—E. R. and F. TURNER Ltd.
Ipswich, England. Z71

WATER SOFTENING & FILTRATION
(FOX PROCESS)
We will report on any sample of water sent to us, free of charge. Estimates free. Apparatus in capacities from 100 gallons to 10,000 gallons hourly. (See large Advertisement in last week's issue.)
GLOVER & HOBSON, Ltd., Engineers
91 & 93, Newington Causeway, London, S.E.
Telephone No. 262 Hop. Z234
Telegraphic Address—"Ironworks, London."

INDICATORS LUBRICATORS
THE LUNKEN VALVE COMPANY,
35, Great Dover Street, LONDON, S.E.
For previous Advt. see last week's issue.
VALVES INJECTORS

GEO. ADLAM & SONS
BRISTOL.
Hydraulic and General Engineers, Coppersmiths,
Brass Founders and Finishers.
Speciality—ELECTRIC LIFTS & PUMPS. Z33

LIDGERWOOD
PILE DRIVING
HOISTING & CONVEYING.
SEND FOR CATALOGUES AND PARTICULARS. Z29
LIDGERWOOD MANFG. CO.,
Caxton House, Westminster, London, S.W.

For Superior Quality Crucible Melted
MALLEABLE IRON and STEEL CASTINGS,
Try T. SMITH & CO.,
Bailey Lane, Sheffield.
"QUICK DELIVERIES." D4

Sugar Refining Machinery.
BLAKE, BARCLAY and CO.,
Gres N.B. sm15

JOHN HANDS & SONS BIRMINGHAM.
FOR PRESSES & SHEARS.
SEE OUR ADVERTISEMENT NEXT WEEK.

S. H. HEYWOOD & CO,
LIMITED,
REDDISH, near STOCKPORT.
We have a 5 & 10 tons 3-motor Crane going through for Stock, hence early delivery. Q618

BARRY HENRY & CO.

Limited,

Founders, Engineers and Millwrights,

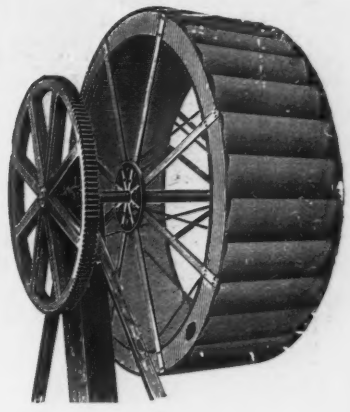
THE LEADING SPECIALISTS FOR THE

TRANSMISSION OF

POWER & MATERIAL

Gear Wheels.
Rope and Belt Pulleys.
Shafting and Fixings.
Engines and
Water Wheels.

Conveyors
of every description.
Elevators,
Strap or Chain,
Complete or Parts.



ABERDEEN.

LONDON OFFICE - - 64, MARK LANE, E.C.

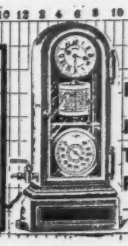
MONDAY TUESDAY WEDNESDAY THURSDAY FRIDAY SATURDAY SUNDAY

160 140 120 100 80 60 40 20

BAILEY'S STEAM PRESSURE RECORDER

SAVES MONEY BY CHECKING CARELESS STOKING.

RECORDS PRESSURES. INDICATES TIME AND PRESSURE.



Two Diagrams in 1/4 natural size, Drum 7in. diam. Clock and Gauge substantially made. Weekly or Daily diagram. Works for years. Not a toy.

COPYRIGHT.

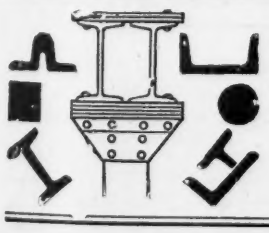
W. H. BAILEY & CO., Ltd., Salford

THE "GARRETT" STEAM MOTOR TRACTOR.

This engine is of special interest to Hauliers, Contractors, Corn Merchants, Millers, Brewers, Furnishers, Market Gardeners, Brick Manufacturers, & Merchants of all sorts (Coal, Iron, Timber, &c.), as it will undoubtedly entirely take the place of horses at a great saving in working expenses to their owners.

GRAND PRIX,
MILAN EXHIBITION
1906.

RICHARD GARRETT & SONS, LTD., LEISTON WORKS, ENGLAND.



C. C. DUNKERLEY & CO., LD.

JOISTS IN EVERY LEADING SECTION FROM STOCK OR FROM WORKS.

COMPOUND GIRDERS, STANCHEONS, &c., RIVETED UP WITH DESPATCH FROM STOCK MATERIALS.

Channels, Flitches, Angles, Tees, Shafting, Bars, and Large Assortment of every description of Iron & Steel required in Engineering Wor

Steel Joists in Stock from 24 x 7½ to 3½ x 1½in. Telegrams—Ajax, Manchester. Telephones—6490 (4 lines). Section Book on application.

Offices & Warehouses: STORE ST., MANCHESTER.

VICKERS, SONS & MAXIM, Ld., Sheffield

LONDON OFFICE: 28 & 32, VICTORIA STREET, WESTMINSTER, S.W.

TOOL STEEL OF ALL DESCRIPTIONS.

BEST CAST STEEL TYRES, CRANK AND STRAIGHT AXLES.

MARINE CRANK AND STRAIGHT SHAFTING AND PROPELLERS.

Solid Cast Steel Crossings, Bells, & Heavy Steel Castings.

Electric Generators, Electric Motors. Complete Equipments for Electric Driving or Lighting of Factories.

CONTRACTORS TO THE BRITISH GOVERNMENT FOR

FINISHED GUNS, GUN FORGINGS, STEEL SHELLS. SOLID STEEL ARMOUR PLATES.

HARTNESS
FLAT TURRET LATHE.

Now built in two sizes—2½ by 24—12in. swing, and 3 by 36—14in. swing. Equipped with tools for either bar or chucking work.

JONES & LAMSON MACHINE CO.

"Jubilee Buildings,"

97, QUEEN VICTORIA STREET,

(COPYRIGHT.) **LONDON.** (Spl. 612

SOLDERING
IS A SIMPLE MATTER
WITH **FLUXITE**

IT'S A PASTE FLUX with which dirty, greasy and even painted metals can be soldered. It does not corrode and can't be spilt. Of Ironmongers, etc., in 6d., 1s & 2s. Tins, with instructions.—Auto-Controller & Switch Co., Dept. F., Bermondsey, London. (Spl.)612

Ebonite. Telegrams—EBONITE, LONDON.

Dr. Heinr. Traun & Sons, 8, Redcross St., London, E.C.

Vulcanite.

MACHINING FOR THE TRADE.

Shafting, Pulleys, and Gear Wheels in Stock.

FORGINGS AND CASTINGS.

Cast Iron Flange Pipes. Cast & Wrot. Iron Tanks

SPECIAL MACHINERY MANUFACTURED.

GENERAL REPAIRS.

JAS. PHILLIPS & CO., Engineers,

Salisbury Street, BERMONDSEY, S.E. 6045

Teleg.—REFITTING, LONDON. Telephone No. 1782 Hop

Gauges.

See our advertisement December 6, Page preceding the one facing editorial matter.

The Newall Engineering Co., Ld.,

Warrington. 1018

QUICK DELIVERY.

Machined if required.

Up to 10 TONS **CASTINGS**

Telegrams—"EASTWALD, TAUNTON." Telephone No. 0146.

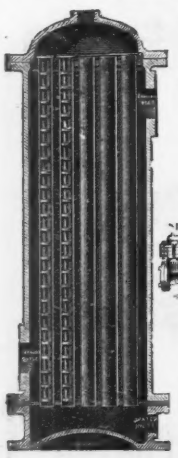
EASTON & BESSEMER,

Z252 **TAUNTON.** LTD.,

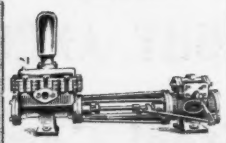
T. SHORE & SONS

Engineers,

STOKE-ON-TRENT.



PATENT FEED WATER HEATERS.



DIRECT-ACTING PUMPS,

VERTICAL AND HORIZONTAL.

Q584

Rowell's Patent Steel Wire Rope

SUSPENSION BRIDGES.

UTILITY. Suspension Bridges are well adapted for many situations, in which, from the limited traffic, the expense of ordinary stone bridges would prevent their adoption, and also for places in which from the great span required, the great elevation, the unfavourable nature of the bottom, or the rapidity of the current to be crossed, the erection of any other kind of bridge would be difficult.

ORIGIN. Though it is only within the last 60 or 70 years that Suspension Bridges have been constructed to any considerable extent, such structures are by no means of recent origin; indeed, the spider solved the problem of Suspension Bridges centuries ago.

We have been established over half a century, and have given this problem careful study. Our bridges are erected in many parts of the world, and, without exception, have given complete satisfaction.

Designs and Estimates on Application to the Pioneers. 6114

DAVID ROWELL & CO.

Estd. of WESTMINSTER. 1855.

PATENT

"GRIPOLY"

SOLID WOVEN

BELTING

(Having Woven-in Indestructible Leather Edges.)

The only Waterproof Textile Belt in the market capable of running under the same conditions as Solid Leather Belting. 50% cheaper at first cost.

Write for full particulars to the Patentees and Sole Manufacturers—

LEWIS & TYLOR, LTD.,

St. Mary's Works, CARDIFF.

TRIAL BELTS ON FREE RUNNING CONDITIONS.

Spl 6114

RICHD. D. BATCHELOR,

ARTESIAN & CONSULTING WELL ENGINEER.

Established over a Century.

CONTRACTOR TO ADMIRALTY AND WAR OFFICE.

Water Supplies.

Largest Steam Well

BORING PLANT.

Electrically-driven Pumps, Engines, and Pumps for Flooded Sinkings. U1896

73, QUEEN VICTORIA ST., LONDON.

Telegrams { BATCHELOR, LONDON. / WATERBORING, CHATHAM. } & ARTOIS WORKS, CHATHAM

Telephone No. 3545 London Wall. Telephone—71 CHATHAM

Save One-third Present Cost.—PURE ENGLISH OAK BARK TANNED LEATHER BELTING, cut out of Prime Selected Butts only (no shoulders), double stretched and carefully manufactured; greatest possible durability, true and steady driving fully guaranteed.

"BEST" SINGLE LEATHER BELTING, ½in. wide, 1d. per foot run; 1in., 1½d.; 1¼in., 2d.; 1½in., 2½d.; 1¾in., 3d.; 2in., 3½d.; 2¼in., 4d.; 2½in., 4½d.; 2¾in., 5d.; 3in., 5½d.; 3½in., 6d.; 4in., 7d.; 4½in., 8d.; 5in., 9d.; 5½in., 10d.; 6in., 11d.; 7in., 1s 1d.; 8in., 1s 3d.; 9in., 1s 5½d.; 10in., 1s 7½d.; 11in., 1s 9½d.; 12in., 2s 0d.; 14in., 2s 4d.; 15in., 2s 6d.; 16in., 2s 8d.; 18in., 3s 0d.; 20in., 3s 4d.; 22in., 3s 8d.; 24in., 4s 0d.

"BEST" DOUBLE LEATHER BELTING: 2in., 11½d. per foot run; 3in., 1s 5d; 4in., 2s; 5in., 2s 6d.; 6in., 3s; 8in., 4s 4d.; 9in., 4s 11d.; 10in., 5s 6d.; 12in., 7s. All other widths at proportionate prices.

Instantaneous despatch, and carriage paid to any station in the United Kingdom.

"Delivery as prompt as if next-door neighbours."

"Your forwarding arrangements seem perfect."

"Of our thirty-seven orders sent you during the last three months, not one late arrival."

"Belting arrived on job (Inverness) in record time."

"Cornwall or John o' Groat's, Connemara or Cape Town—wherever our men go to fix our machines, your belting gets there on time."

"Ordered by wire late of an afternoon even, the belting always reaches us next morning."

Perfection of Material and Manufacture.

"Best we ever had."

"Under the hardest of hard wear, good as new yet.

A Saving of One-third in the Price.

"Must admit is both 'best' and cheapest.

"Shall send you all our orders."

Carriage paid to any address (or nearest station) in Great Britain, or put f.o.b. any home port.

BEST BELTING CO., Limited,

13, Cullum-st., Fenchurch-st., London, E.C.

London Manager—DAVID ROBINSON. Nat. Telephone 959 Avenue. Telegrams: "Notwithstanding, London." Spl 6034

STABLEFORD & CO., LTD.,

COALVILLE.

RAILWAY CARRIAGE & WAGON BUILDERS,

For Home & Foreign Lines.

BRAKEWORK, FORGINGS, CASTINGS, &c.

Telegrams—Stableford, Coalville.

Registered Office—
26 & 27, Exchange Bldgs., BIRMINGHAM.
Tel.: Stableford, Birmingham Nat. Tel. 591.

CAMPBELLS & HUNTER

LIMITED,

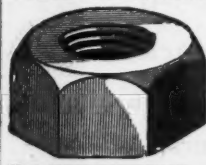
DOLPHIN FOUNDRY, LEEDS,

MAKERS OF

RADIAL DRILLING AND TAPPING MACHINES.
HORIZONTAL DRILLING, TAPPING AND BORING MACHINES.
MULTIPLE DRILLING MACHINES.
BOILER SHELL DRILLING MACHINES.
TUBE PLATE CUTTING-OUT MACHINES.
ROUND & OVAL HOLE CUTTING-OUT MACHINES AND PLATE FINISHIN MACHINES.
CIRCULAR PLANING, SLOTTING AND DRILLING MACHINES.
VERTICAL BENDING ROLLS Spl 6076

EDWARD MERCER

Hollins Ironworks Hollinwood, near Manchester.



Speciality:

BRIGHT SHAPED

HEXAGON NUTS

Which for high quality, finish, and lowness of price remunequalled. Guaranteed accurate to Whitworth's Standard. Prices and samples on application. As supplied to Government. W1155

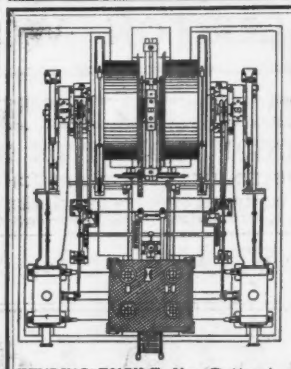
COOLING TOWERS.

Baleke's Patents.

BALCKE & CO., London E.C.

Clements House, Clements Lane. 8051

See Illustrated Advertisements last and next week.



WINDING AND HAULING ENGINES.

GRANT, RITCHIE & CO.,

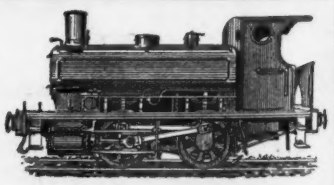
LIMITED,

KILMARNOCK, N.B.

ENGINEERS,

IRONFOUNDERS AND BOILERMAKERS.

Locomotives, Pumping Plant,
Corliss & other Winding & Hauling Engines,
Compound Corliss Driving Engines,



TANK LOCOMOTIVE.

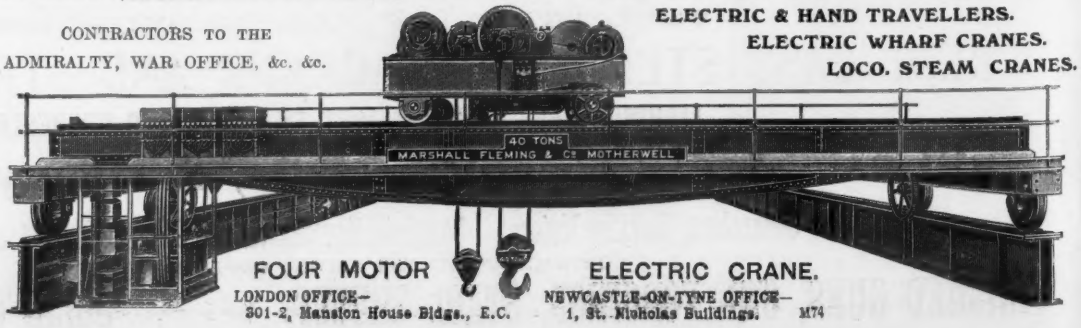
Full Particulars, Prices and Specifications on application. SM21

WINDING ENGINE (New Pattern). **Rope Clip Pulleys & Friction Clutches, Mine Fans, Coal Cutters, Coal Cleaning Plant, &c. &c.**

MARSHALL, FLEMING & CO., Engineers, MOTHERWELL.

CONTRACTORS TO THE ADMIRALTY, WAR OFFICE, &c. &c.

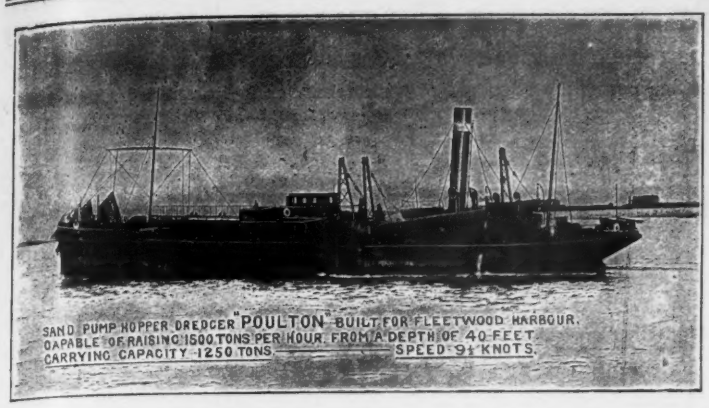
ELECTRIC & HAND TRAVELLERS.
ELECTRIC WHARF CRANES.
LOCO. STEAM CRANES.



FOUR MOTOR ELECTRIC CRANE.

LONDON OFFICE—
301-2, Mansion House Bldgs., E.C.

NEWCASTLE-ON-TYNE OFFICE—
1, St. Nicholas Buildings. M74


SAND PUMP HOPPER DREDGER "POULTON" BUILT FOR FLEETWOOD HARBOUR.
CAPABLE OF RAISING 1500 TONS PER HOUR FROM A DEPTH OF 40 FEET
CARRYING CAPACITY 1250 TONS
SPEED 9½ KNOTS.

DREDGER PLANT (IMPROVED PATENT.)

INVENTORS AND SOLE PATENTEES OF THE INDEPENDENT

TRAVERSING BUCKET LADDER,

To enable Dredgers to cut in advance of hull, and so make their own flotation.

INVENTORS AND CONSTRUCTORS OF MOST

Improved Hopper Dredgers.

Builders of Bow and Stern Well Hopper Dredgers, Suction Pump Dredgers, Barge Loading Dredgers, Gold Recovering Dredgers and Machinery, Steam Hopper Barges, Side and Stern Paddle Wheel Steamers, New Buckets, Gearing, Links, Pins, &c., supplied, or fitted to existing Dredgers.

FLEMING & FERGUSON, Ld.

Shipbuilders and Engineers, PAISLEY, N.B.

(Spl.) 7022 LONDON OFFICE: 9, FENCHURCH AVENUE, E.C.

Telephone— 49 Darlaston.

Telegrams— Crito, Willenhall.

We Specialise ON HIGH-GRADE

DROP FORGINGS

OF UNIFORM QUALITY, ACCURACY & FINISH.

J. B. BROOKS & CO., Ltd., Criterion Works, WILLENHALL. Q621 ENQUIRIES INVITED.

"PARALLEL FLOW"

IS THE BEST SYSTEM OF

OIL SEPARATION

Highest Efficiency without Loss of Vacuum

In most systems a heavy price is paid for High Separation Efficiency in a corresponding loss of Vacuum.

Our system of Separation gives a maximum of efficiency with a minimum of resistance.

Our New Catalogue, No. 127a, explains the how and why of this fact. Send for it.

HOLDEN & BROOKE, Ld., Sole Manufacturers,

Sirius Works, West Gorton, MANCHESTER. X1024

SIEBE, GORMAN & CO., LD.

Neptune Works, LONDON, S.E.

Established 1820. 22 Gold Medals.

TWO GRAND PRIZES, MILAN, 1906.

DIVING APPARATUS,

DRESSES, HELMETS, PUMPS, &c., Of all Patterns.

Sole makers to the BRITISH ADMIRALTY, War Office, India Office, Crown Agents, Trinity Corporation, &c.

Teleg. Address—SIEBE, LONDON. Telephone—No. 361 (Rop).

SAVE FUEL AND LABOUR.

KEEP PISTON RODS TRUE.

"THE LANCASTER" R.T.M.

Metallic

PACKINGS.

FIRST ORDERS SENT "ON APPROVAL."

ILLUSTRATED CATALOGUE SENT POST FREE.

LANCASTER & TONGE, LD.,

Sole Makers of "The Lancaster" Pistons, Steam Traps, Steam Dryers, &c.

PENDLETON, MANCHESTER.

SIMPLE, RELIABLE, AND DURABLE.

SUPPLIED TO BRITISH NAVY.

W. H. WILLCOX & CO. LIMITED.

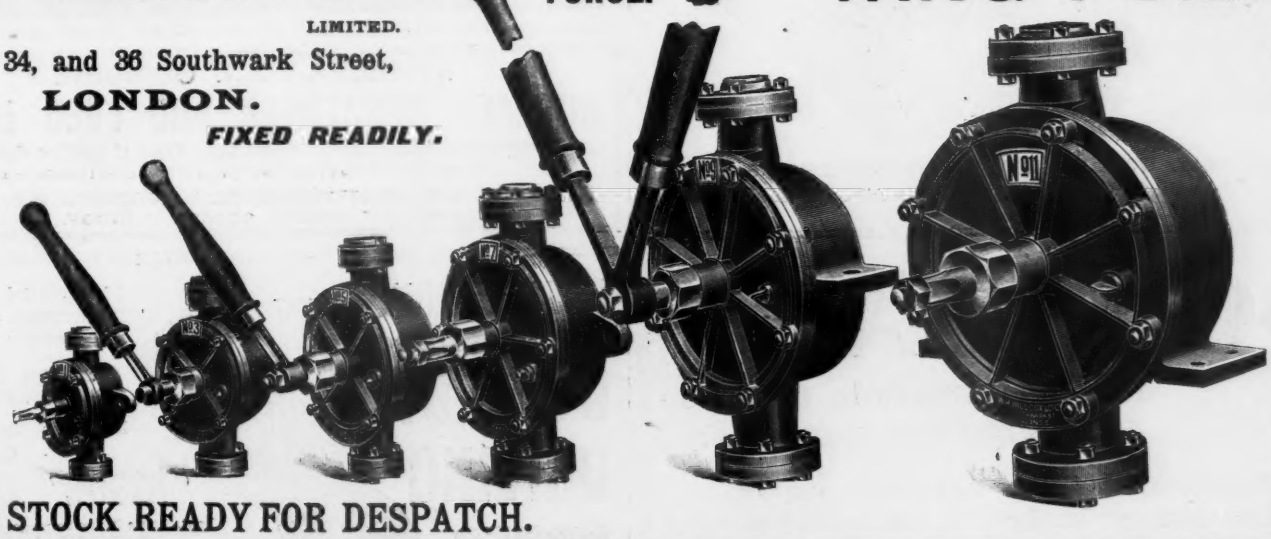
23, 32, 34, and 36 Southwark Street, LONDON.

FIXED READILY.

LIFT AND FORCE.

Willcox's Semi-Rotary

WING PUMPS.



16 SIZES IN IRON AND BRASS

4780

Double and Quadruple Acting.

—

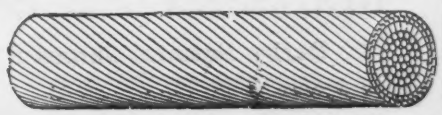
Adopted by the Government and fixed by Engineers all over the world

4000 IN STOCK READY FOR DESPATCH.

LOCKED WIRE ROPE

SMOOTH SURFACE

VERY FLEXIBLE



MANUFACTURED BY

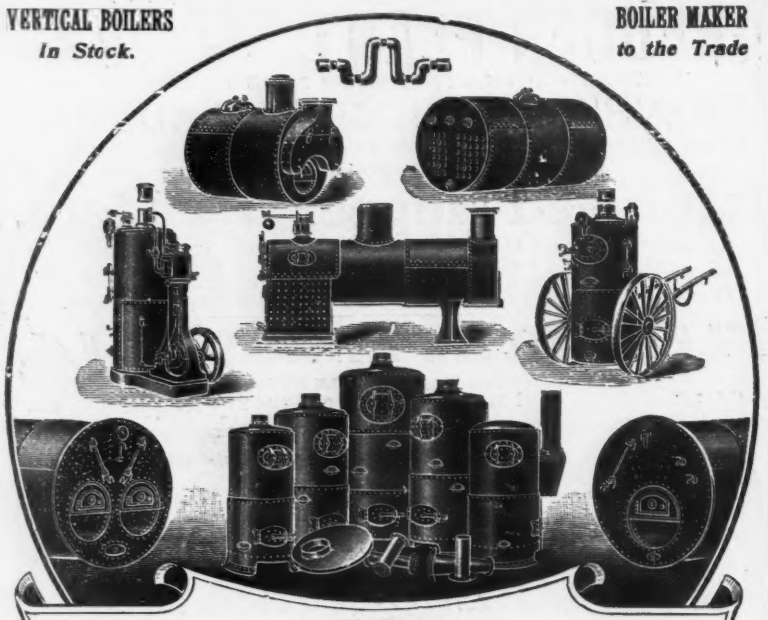
GEORGE ELLIOT & CO., Ltd. Works: CARDIFF.

Office—16, Great George St., Westminster, London.

DOES NOT TWIST IN WORKING

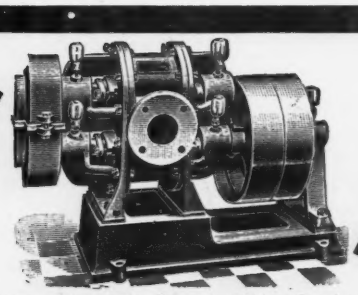
VERTICAL BOILERS
In Stock.

BOILER MAKER
to the Trade



THE
GRANTHAM BOILER & CRANK Co. LTD.
GRANTHAM.

THE DRUM PUMP Johnson's Patents



For quickly and economically moving large quantities of water, semi-fluids, &c.
POSITIVE ACTION. HIGH PERCENTAGE OF EFFICIENCY.
NO VALVES TO GET OUT OF ORDER.
Largely used by Dyers, Brewers, Paper Makers, Sugar Refiners, Soap Makers, &c.
Telegrams—Drum, Bradford. Write for Descriptive Catalogue No. 50. (Spl) 1115
DRUM ENGINEERING CO., 33, BROOK ST., BRADFORD.

WROUGHT IRON PLATE WORK OF ALMOST EVERY DESCRIPTION, GALVANIZED OR UNGALVANIZED, UNDERTAKEN. (Spl) 095

OIL GAS

FOR ILLUMINATING, HEATING, OR DRIVING GAS ENGINES. . .

Mansfield's Oil Gas Apparatus makes Gas from any kind of Oil, Fat or Grease.

MANSFIELD & SONS, LTD.

Derby Square, James Street, LIVERPOOL.

Also at MADRAS & CAIRO.

Seamless Copper Jointings

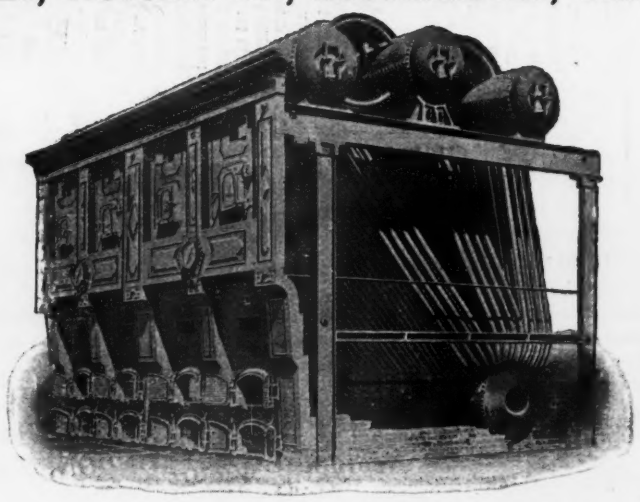
ANY SIZE. ANY SHAPE. CUT from SOLID SHEET. MACHINED ALL OVER.

Can be constantly re-used. Do not char, corrode, eat away, or adhere to flanges. No red-lead or other filling!

For Cylinder Valve-chest or Mud-hole Covers and all High Pressure Joints. Applied and removed without use of tools.
Avoid CAST or STAMPED imitations.

THE HULBURD ENGINEERING CO.,
Contractors to H.M. Government, Brassfounders and Coppersmiths
150, LEADENHALL STREET, LONDON, E.C. E013

THE
STIRLING BOILER Co., Ld.
Telegrams—STIRLINICO, LONDON. Telephone—Nos. 559 & 822 WESTMINSTER
Head Office—
25, VICTORIA ST., WESTMINSTER, S.W.



3,000,000 HORSE-POWER IN STIRLING BOILERS NOW WORKING.

Specially suitable for firing by Blast Furnace Gas, and for utilising Waste Heat from coke ovens, &c.

HIGHEST ECONOMY, SMALL FLOOR SPACE, LOW FIRST COST AND MAINTENANCE.

Largely Used in Electric Light and Power Stations, Engineering, Iron and Steel Works and Collieries.
Branch Offices: London, Manchester, Leeds, Newcastle.

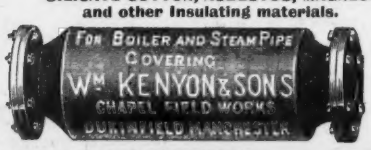
WHEELER-VOLZ COMBINED
SURFACE CONDENSER AND FEED HEATER
Is more Economical than the Ordinary Type of Surface Condenser.
Write us for full particulars, we have a special offer to make you.
WHEELER CONDENSER & ENGINEERING Co.
2, NORFOLK STREET, STRAND, LONDON, W.C. Y424

KENYON'S PATENT
INTER-STRANDED
COTTON DRIVING ROPES

Telephone—30 Ashton.
Telegram—Kenyon, Dukinfield.
WM. KENYON & SONS, LTD.,
Chapelfield Works,
DUKINFIELD, near MANCHESTER.

Illustrated Lecture, "Transmission of Power by Ropes," post free.

BOILER COVERING DEPARTMENT.
Kenyon's Specially Compounded
"KISOL" CEMENT
1 cwt. Sample Bag sent carriage paid to any address in the United Kingdom for 7s. 6d.
SILICATE COTTON, ASBESTOS, MAGNESIA, and other Insulating materials.



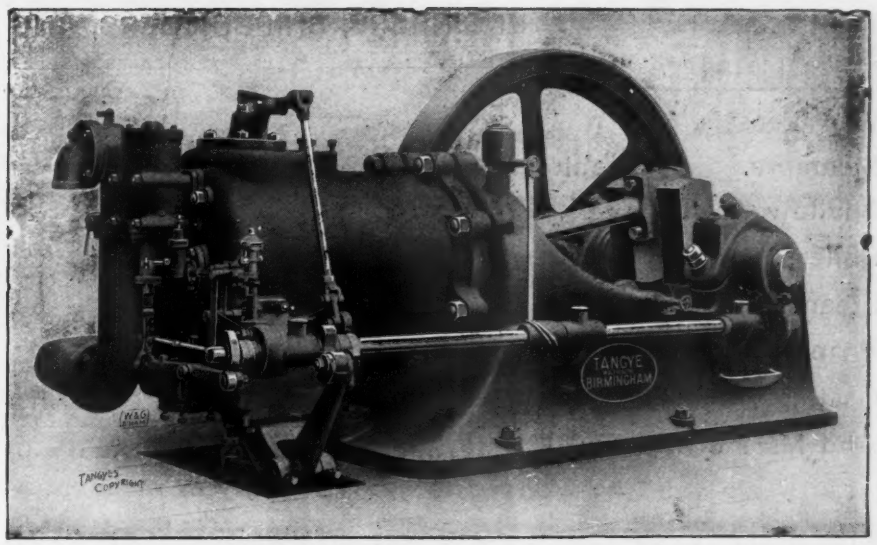
ASK FOR "HINTS ON BOILER COVERING." Q601

TANGYES LTD BIRMINGHAM.

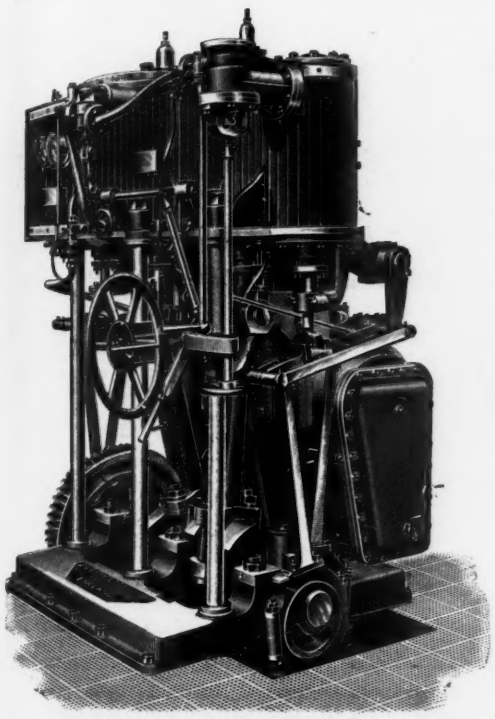
Engines

for **Town** or

'Suction' Gas.



U60 300 A



PLENTY & SON,

LIMITED,

Engineers, NEWBURY, ENGLAND.

Established 1790. **Telegraphic Address—PLENTY, NEWBURY.**

Contractors to the Admiralty, War Office, Crown Agents for the Colonies, Indian Office, Trinity Board, Customs House, and various Foreign & Colonial Governments

MAKERS OF ALL CLASSES OF

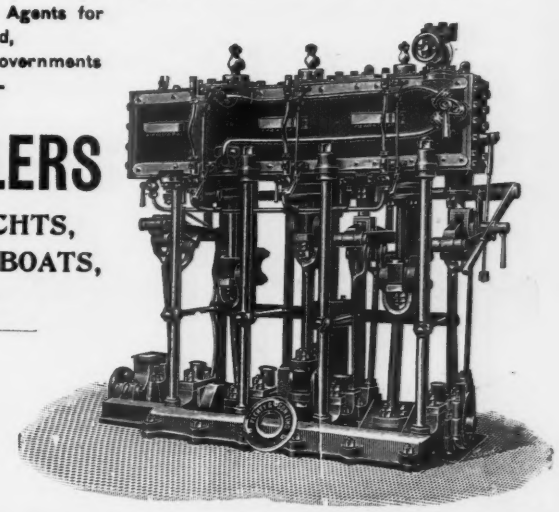
ENGINES AND BOILERS

For SMALL STEAMERS, YACHTS, TUGS, LAUNCHES, TORPEDO BOATS, HOPPER BARGES, &c.

WATER-TUBE BOILERS

Of "Mumford," "Thornycroft," "Yarrow," and other Types. H157

ENGINES FOR ELECTRIC LIGHTING.



LARGEST MAKERS OF CAST IRON TANKS

IN THE KINGDOM.

BRANCH OFFICES.

6, Great George St., Westminster, LONDON, S.W.
Grosvenor Buildings, Deansgate, MANCHESTER
50a, Lord St., LIVERPOOL.
Moorhead, SHEFFIELD.

— —

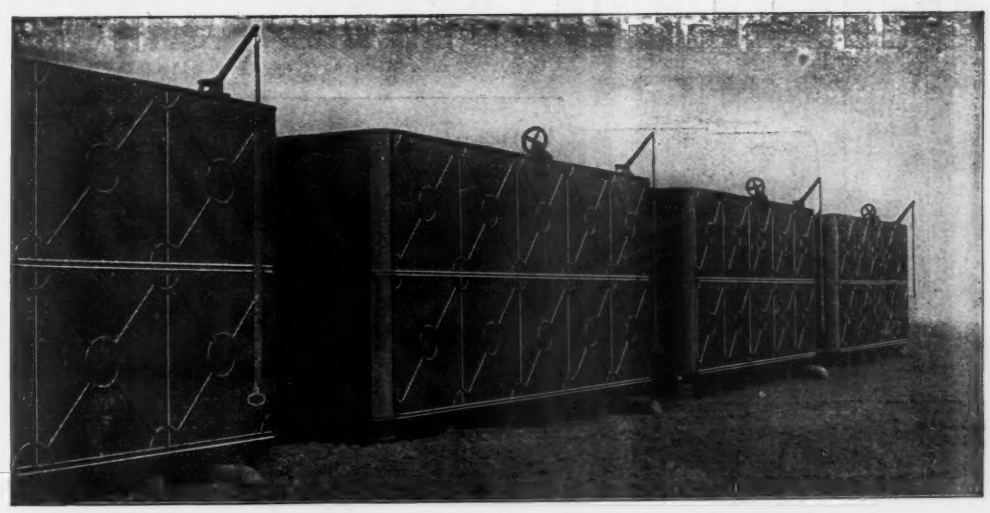
All plates planed full width of flanges.

Tanks of any size supplied and erected anywhere.

DRAWINGS, SPECIFICATIONS, AND ESTIMATES GIVEN UPON APPLICATION.

Contractors to the Admiralty, War Department and Crown Agents for the Colonies.

TELEGRAMS—"NEWTON," SHEFFIELD. T74



NEWTON, CHAMBERS & CO., Ltd., THORNCLIFFE IRONWORKS, near SHEFFIELD.

B

JOHN I. THORNYCROFT & CO. Limited.

ENGINEERS, SHIPBUILDERS, AND BOILER MAKERS,

SOUTHAMPTON (Woolston Works)

War Vessels.
Steamers. Yachts.
Shallow Draft Vessels.
Boilers.
Steam Engines.
Propellers.
Castings,
And Marine Repairs.

One of seven Ferry Steamers for the Hooghly, delivered in pieces and re-erected at Calcutta. Length 100ft. Beam 20ft. Draft 5ft. Speed 12 knots. Passenger capacity 250.

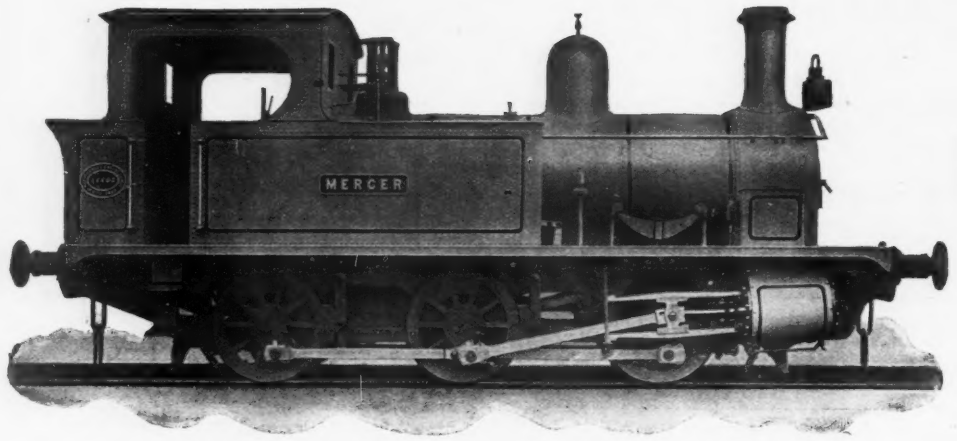
CHISWICK & BASINGSTOKE

Marine Motors.
Motor Boats.
Electric Lighting Sets.
Motor Lorries & Vans for Light and Heavy Loads.
Motor Omnibuses.
Motor Cars.
Portable Boilers.

We shall be pleased to quote for any of the above Specialities on application to us at—

Church Wharf, CHISWICK. | Woolston Works, SOUTHAMPTON. | Motor Vehicle Dept., 2, Albemarle Street, W.

THE HUNSLET ENGINE CO. LIMITED.



LEEDS.

Makers of

LOCOMOTIVE ENGINES

adapted to every variety of work and gauge.

Designs and Specifications Supplied or worked.

Quotations and Specifications on application.

Telegraphic Address—ENGINE, LEEDS.

Telephone—No. 528.

CHILLED AND GRAIN ROLLS

C. AKRILL & CO., LTD.,

Gold's Green Foundry, West Bromwich.

MAKERS OF ALL CLASSES OF

ROLLING MILL MACHINERY & GENERAL CASTINGS USED IN STEEL, IRON & METAL WORKS.

&c. Q367

Telephone No. 3, West Bromwich. Nearest Passenger Station, G.W. and L. & N.W.—Great Bridge. Telegrams—Akrill, Limited, West Bromwich

ALLAN, WHYTE & CO.,

Clyde Patent Wire Rope Works,

RUTHERGLEN, GLASGOW,

SCOTLAND.

Telegrams: "ROPERY, RUTHERGLEN."

Codes: A B C (4th and 5th), A1, LIEBER'S, and PRIVATE.

Telephones: 2673 and 2674 BRIDGETON (NATIONAL) and 2673 POST OFFICE.

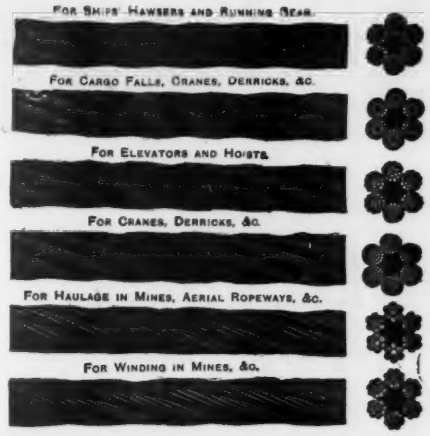
London Office:

5, EAST INDIA AVENUE, LEADENHALL ST., E.C.

Telegrams: "ALKALIZE, LONDON."

Telephone 299 AVENUE

Johannesburg Office: CONSOLIDATED BUILDING, FOX & HARRISON STREETS (P.O. Box 507). Telegrams—HAULAGE. Telephone 566


FOR SHIPS' HAWSERS AND RUNNING GEAR.
FOR CARGO FALLS, CRANES, DERRICKS, &C.
FOR ELEVATORS AND HOISTS.
FOR CRANES, DERRICKS, &C.
FOR HAULAGE IN MINES, AERIAL ROPEWAYS, &C.
FOR WINDING IN MINES, &C.

A FEW OF THE PRINCIPAL CONSTRUCTIONS.

Wire Ropes

FOR

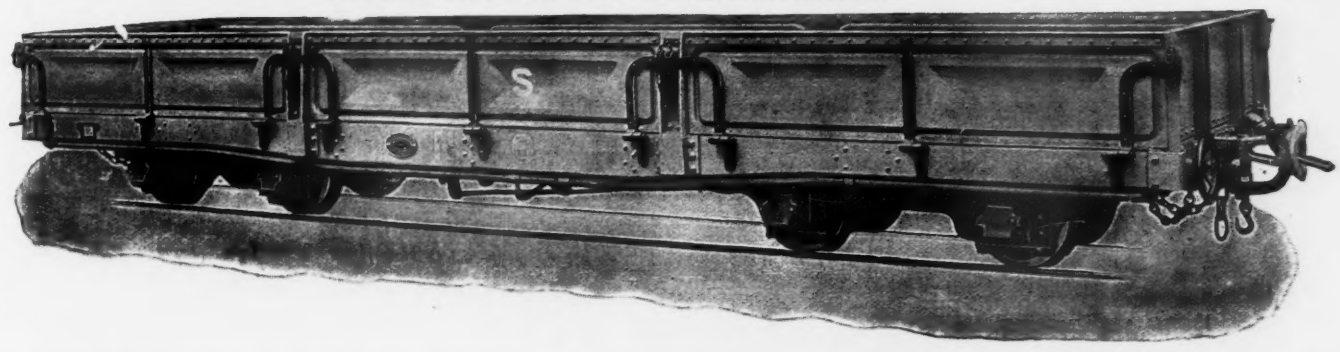
COLLIERIES, MINES, CABLEWAYS,
AERIAL ROPEWAYS, SUSPENSION BRIDGES,
TRANSMISSION OF POWER, HOISTS, CAPSTANS
CRANES, SHOOTWAYS,
SHIPPING, STEAM TRAWLING, &c.

Principal Sizes and Constructions always in stock.

Contractors to the Admiralty, War Office, and Colonial Governments. (and) 1188

THE LEEDS FORGE Co., LTD., LEEDS

London Office—Caxton House, Westminster



THOS. FIRTH & SONS, Ltd.

SHEFFIELD.

LONDON OFFICE: 8, THE SANCTUARY, WESTMINSTER, S.W.

ARMOUR-PIERCING PROJECTILES.

FORGED STEEL TORPEDO AIR VESSELS.

GUN FORGINGS.

CONTRACTORS to the British Admiralty, War Office, India Office, Colonial and Foreign Governments.

TELEGRAMS—"FIRTH, SHEFFIELD," "MESMERIC, LONDON." TELEPHONES—3230 to 3235 SHEFFIELD; 681 WESTMINSTER. X1751

REES "RoTURBo" PUMPS

TRADE MARK.

REES "ROTURBO"

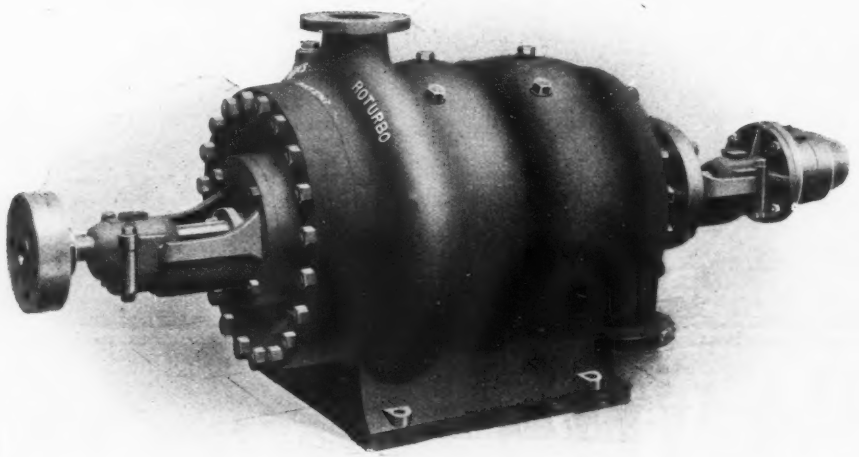
PATENT

SELF REGULATING PUMPS

— A NEW TYPE. —

THE only true Turbine Pump. Self-Regulation and the Highest Efficiency are obtained by means of a **Revolving Pressure Drum** or **Hydraulic Accumulator** of large capacity, obviating the necessity or the usual delicate Vanes and Cutwaters in the Impeller and fixed casing and overcoming the tendency to wear.

The pressure is extracted from the Pressure Drum by an application of the Venturi Transformer Law, converting **Pressure** to **Velocity**, and **Velocity** back to **Pressure**, part of the Velocity being used for Turbine or Self-Propelling Effect, to get Self-Regulation and constant power under all heads.

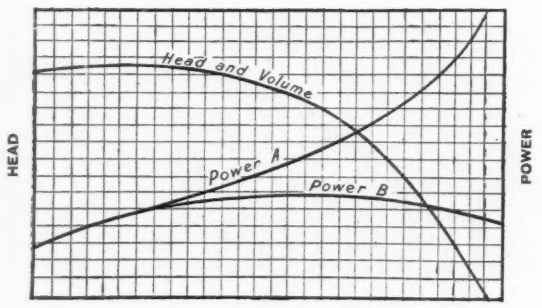


HIGH LIFT ROTURBO COLLIERY PUMP. 600 Feet Head.

COMPARISON OF POWER CURVES.

A ORDINARY TURBINE PUMP.

B REES ROTURBO PUMP.



CONSTANT SPEED, VARYING HEAD AND CAPACITY.

SPECIFICATION:

CONSTANT SPEED. CONSTANT POWER.

VARIABLE HEAD SUCTION LIFT AND VOLUME.

HIGH AND PERMANENT EFFICIENCY.

For Full Description of Pumps see "The Engineer," May 17th, 1907.

OR COMMUNICATE WITH

THOMAS PARKER LIMITED,

ELECTRICAL & MECHANICAL ENGINEERS,

WOLVERHAMPTON.

Telegrams—"COILS." **Telephone—34.** Q497

SOLE MANUFACTURERS FOR

THE REES "ROTURBO" DEVELOPMENT SYNDICATE, LD.

KERR STUART & CO. LD.

1 & 2, BROAD STREET PLACE,
LONDON, E.C.

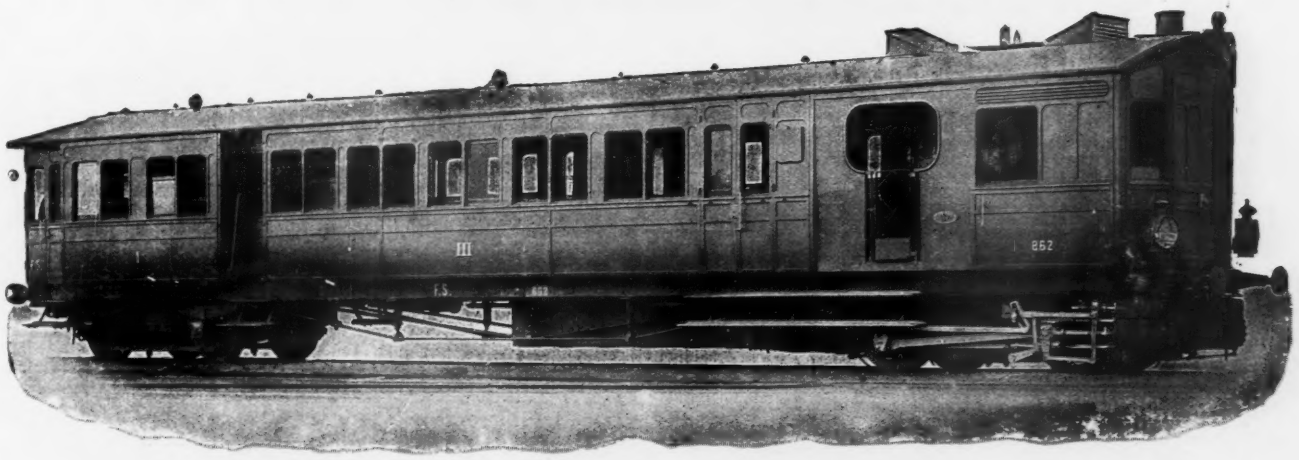
CALIFORNIA WORKS,
STOKE-ON-TRENT.

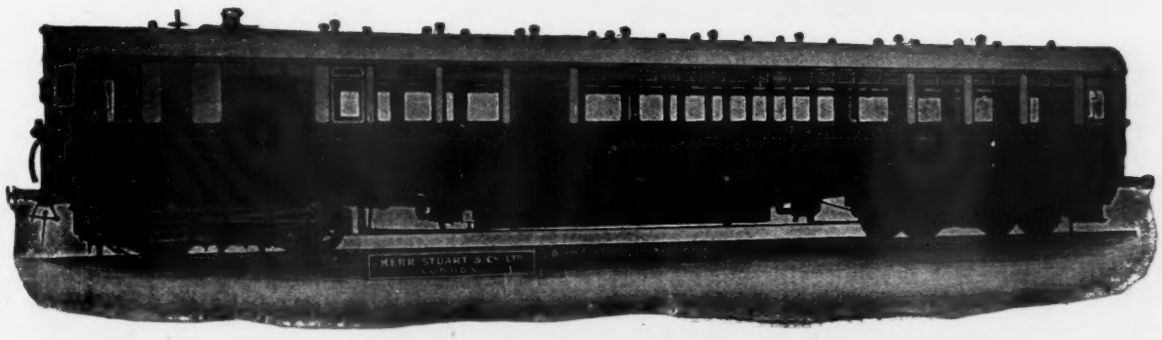
(All Communications to be addressed to London.)

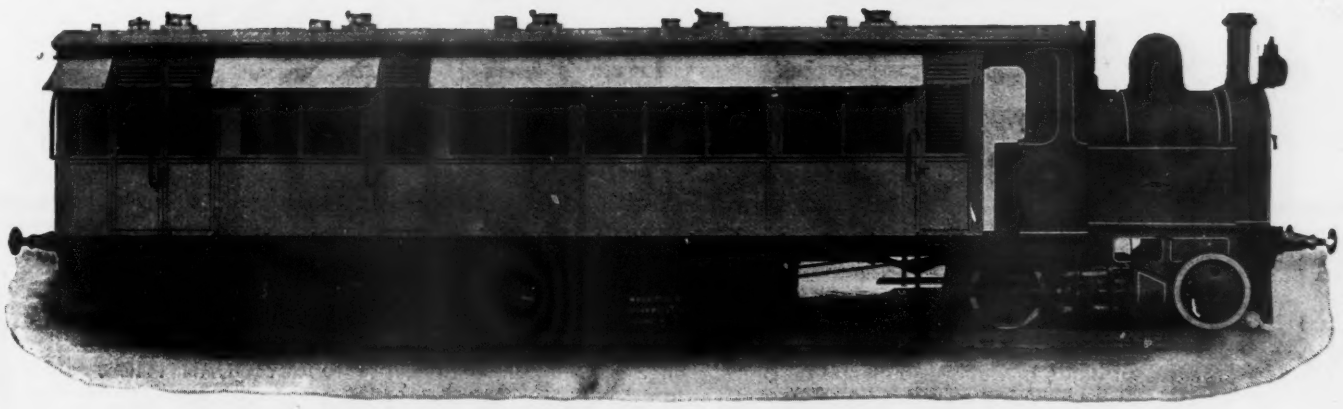
TELEPHONE No.—POST OFFICE, CENTRAL, No. 13,190.

Telegrams—MELISS, LONDON.

LOCOMOTIVES, STEAM SALOONS, WAGONS, CROSSINGS, TURNTABLES, & ALL RAILWAY REQUIREMENTS.







ESTIMATES GIVEN ON APPLICATION for SPECIAL TYPES and for STANDARD LOCOMOTIVES, &c.

A number of the latter are kept in Stock or in an advanced stage of construction.

WILLIAM BAIN & CO.,

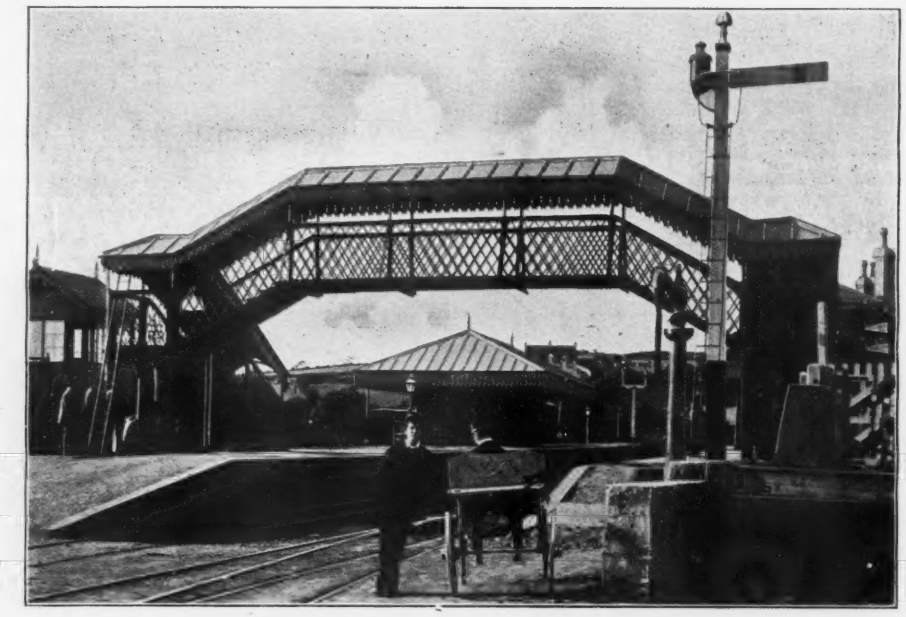
LOCHRIN IRONWORKS,
COATBRIDGE, N.B.

TIMBER-FRAMED
BUNGALOWS,
CHURCHES,
HOSPITALS.

FENCING,
RAILINGS,
AND
GATES.

CONTRACTORS to—
The Admiralty, Crown Agents and War-office.
Home, Colonial and Foreign Railways.

DESIGNS AND ESTIMATES ON APPLICATION.



Footbridge and Station Building erected at Tenby

Constructional Engineers.

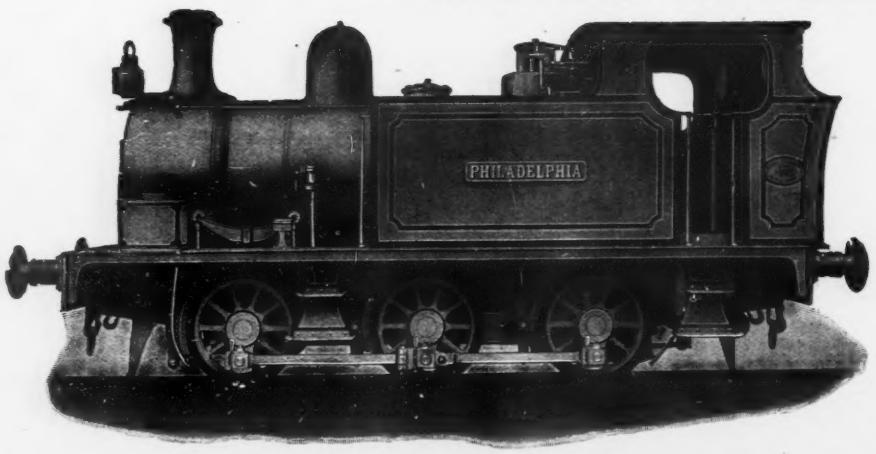
ROOFS,
BRIDGES,
WORKSHOPS,
PIERS,
PITHEAD GEARS
AND
Structures of all Kinds.

LONDON OFFICE:
122, CANNON STREET

ESTABLISHED 1860.

HUDSWELL, CLARKE & CO., LIMITED,

RAILWAY FOUNDRY, LEEDS.



LOCOMOTIVE ENGINES

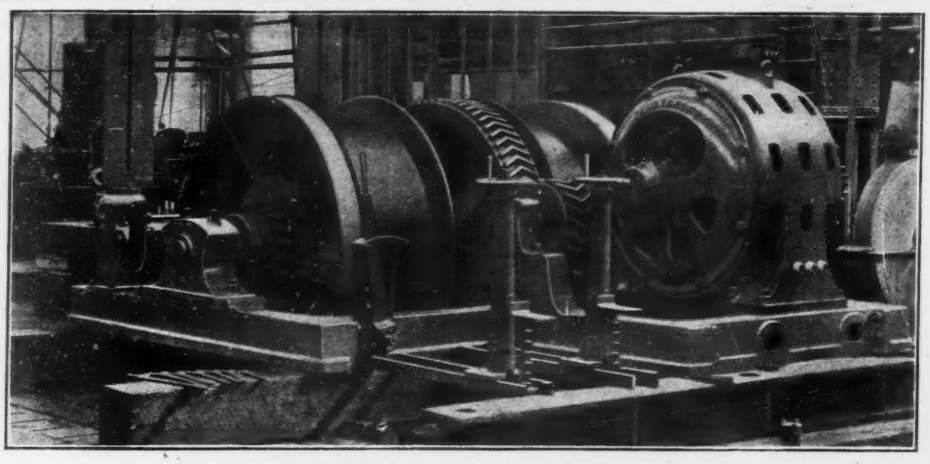
FOR MAIN OR BRANCH RAILWAYS.

Contractors, Ironworks, Collieries, &c.

All Sizes and to suit any Gauge of Railway.

Prices, Photographs, and full Specifications on application.

Telegrams—LOCO, LEEDS. Telephones—NATIONAL 504 & 806
Codes—A1 LIEBERS; A B C, 4th and 5th Edition



Winding Engine & Induction Motor.

PUMPS.
CAPSTANS.
WINDING ENGINES.
GENERATORS. MOTORS.

THE SANDYCROFT FOUNDRY CO., LTD., CHESTER.

ELECTRICAL AND MINING MACHINERY

X1909

MACHINE MOULDED GEARING.

Spur, Bevel, Helical, Mortice, Mitre, and Worm Wheels, Cast or Cut Teeth in IRON or STEEL.
Also all kinds of Pulleys for Rope or Belt Driving. ESTIMATES GIVEN FOR ANY QUANTITIES.

ENGINEERS' CASTINGS up to 20 Tons Cast in Loam or Sand.

JOSEPH HENRY, LTD.

Offices—Manor Road, Holbeck, Leeds.

Branches: Manor Road Foundry, HOLBECK.
Larchfield Foundry, HUNSLET.

Late Messrs. Holroyd, Horsfield, and Wilson. D25

CAMMELL LAIRD AND CO., LIMITED,

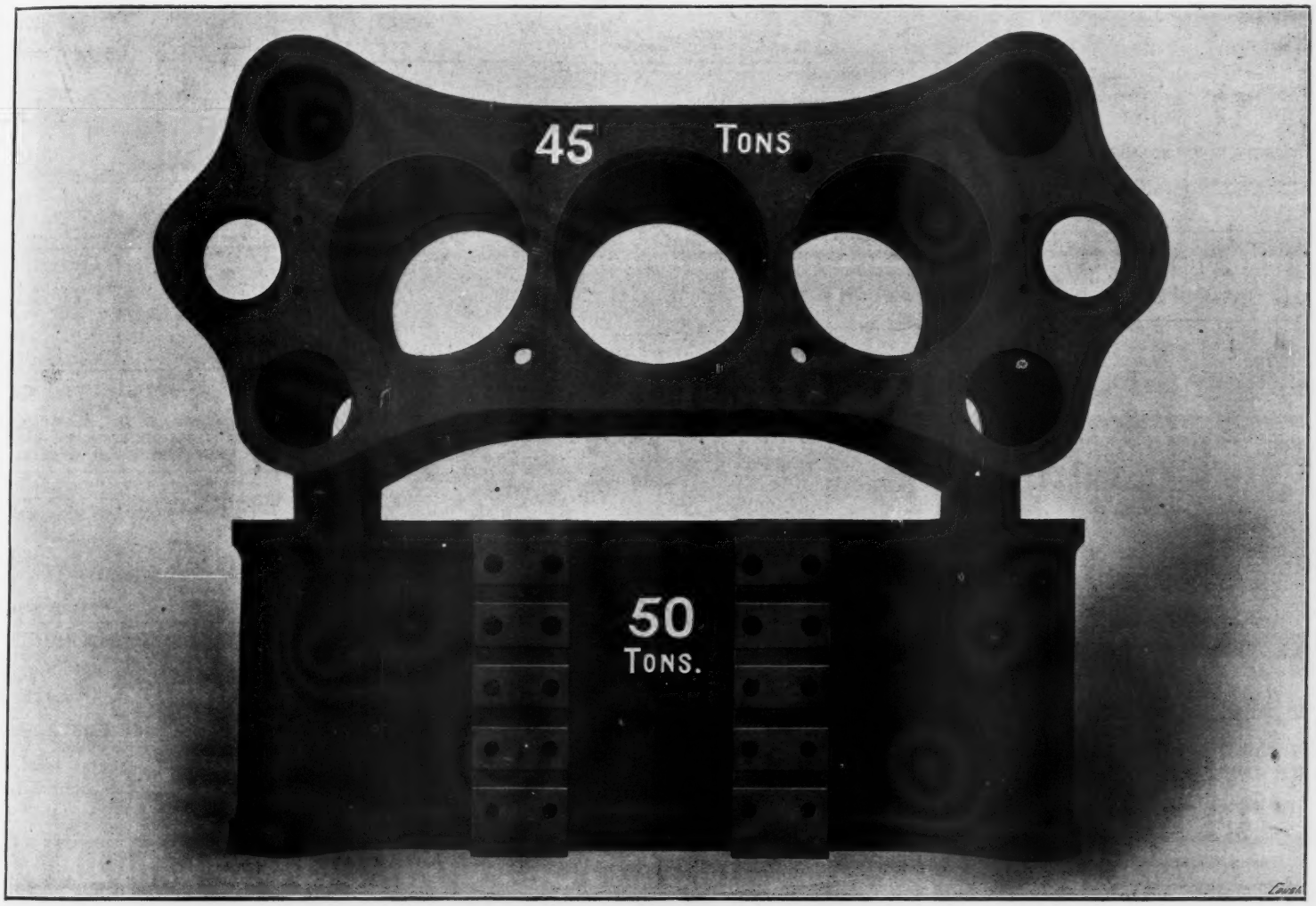
Steel Manufacturers, Shipbuilders, and Engineers.

Head Office: CYCLOPS IRON & STEEL WORKS, SHEFFIELD,

AND

GRIMESTHORPE ORDNANCE, STEEL, TYRE, & SPRING WORKS, Sheffield
YORKSHIRE STEEL and IRON WORKS, Penistone.
DERWENT IRON and STEEL WORKS, Workington.
LOWTHER IRON WORKS, Workington.
SOLWAY IRON WORKS, Maryport.
NEW OAKS COLLIERIES, near Barnsley.
SHIPYARD and ENGINEERING WORKS, Birkenhead.

LONDON OFFICE: 9, VICTORIA ST., S.W.



STEEL CASTINGS (MACHINED)

To order of MESSRS. DAVY BROS., LTD., SHEFFIELD, for 4000 TON FORGING PRESS.

MANUFACTURERS OF RAILS, FISHPLATES AND ACCESSORIES.

TYRES, STRAIGHT & CRANK AXLES, SPRINGS

(Laminated, Spiral, and Volute), and BUFFERS to meet new requirements.

Locomotive, Carriage, and Wagon Wheel Centres, and Castings.

STEEL CASTINGS & FORGINGS for TURBINES and all other purposes.

ANCHORS, PROPELLERS, STERN POSTS, CRANK AND STRAIGHT PROPELLER SHAFTING.

PROJECTILES, ARMOUR PLATES, BULLET PROOF PLATES.

CYCLONE HIGH SPEED STEEL SPECIAL "H.R.D." STEEL FOR WORKING ON VERY HARD MATERIAL. "0172" HIGH SPEED STEEL, FOR TWIST DRILLS, MILLING CUTTERS, &c.

FILES AND RASPS.

Sole Licensees and Makers in Great Britain of the "ABT" System of Rack Railway for Steep Grade Lines.

A MARVEL IN METALS.

'Silvo'

A NEW ALLOY MADE FROM METAL CHEMICALLY COMBINED UNDER A SECRET PROCESS.

For Sanitary and Water Fittings, Railway, Motor Car, and Tramway Work, Sheets, Rods, Wire, Solid-drawnor Brazed Tubes, Boiler Stay Rods, and Castings of all kinds.

Messrs. Kirkaldy's test of a "SILVO" Tube gives a tensile strain of 42 tons per square inch, and a bursting pressure of 3645 lbs. per square inch.

"SILVO" BRAND MANGANESE BRONZE

and other "SILVO" metals, made by same secret process, give fine results in engineering work of all kinds.

"SILVO" is rustless, and unaffected by sea water, acids, &c., while its strength is greater than that of steel, and its polish like silver.

Compare the severe tests applied to "SILVO" with the tests that are or ever have been made.

Descriptive Circular Post Free from the

British Bronze and 'Silvo' Metal Co., Ld.

Late the

Birmingham Foundry Co.

London Offices:

34, OLD BROAD ST., E.C.

Telegrams { "Birfoco, London." "Demotic, Birmingham"

Works:

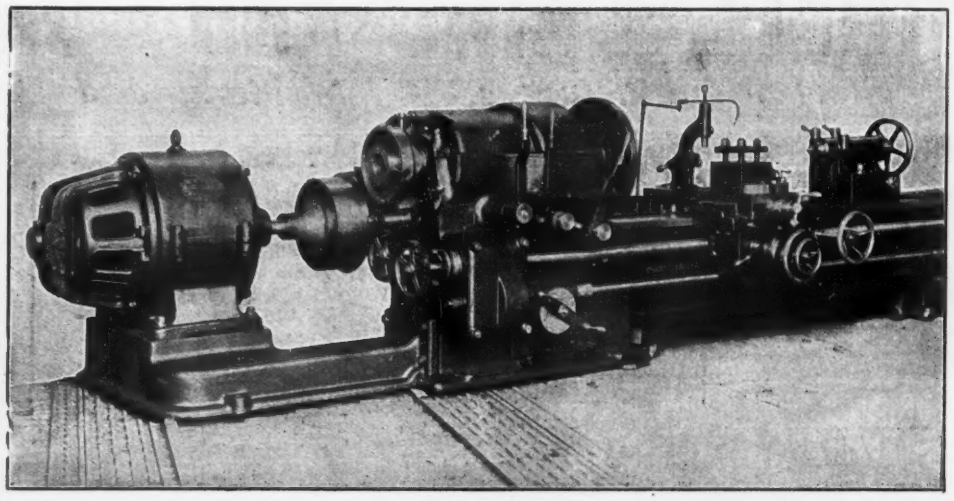
Pritchett St., Birmingham.

Telephone—4797 Central, London

D20 P.A.B

JOHN STIRK & SONS, LD.

HALIFAX. (EST. 1866.)



10in. High Speed Lathe. All-gear Headstock, easily takes a cut $\frac{5}{16}$in. × $\frac{1}{4}$in. at 90ft. per minute

Q446

ANDW. HANDYSIDE & CO., LTD.

Bridges, Roofs, and Structural Steelwork.

Britannia Works, DERBY. | Managing Director, A. BUCHANAN, M.I.C.E. | 104, Queen Victoria St LONDON.

MIDLAND STATION. NOTTINGHAM.
Area, 99,850 square feet. Weight, 1000 tons.

SUPER HEATED STEAM

SEND for CATALOGUE of SPECIALITIES
VALVES CUT ENGINES Q615
The SHEPPEE MOTOR CO., Thomas St., YORK.

Established 1870.

Works—
PHŒNIX IRON WORKS,
Govan, Glasgow.

Tel. Address—
Steelwork Glasgow

G. B. SMITH & CO.,
STRUCTURAL ENGINEERS,
Manufacturers of Steel and Iron Roofs, Composite Buildings, Bridges. zz43
Also Iron Fencing, Railing, Gates, &c.

STOCK BOILERS.

Over THIRTY THOMPSON DISH-ENDED LANCASHIRE BOILERS,
of Various Sizes, including 9ft. 3in. diar., 160 lbs. w.p.
READY FOR PROMPT DELIVERY.
Ask for Detailed Stock List. E145
JOHN THOMPSON, Wolverhampton.

WELLMAN

CLUTCH.

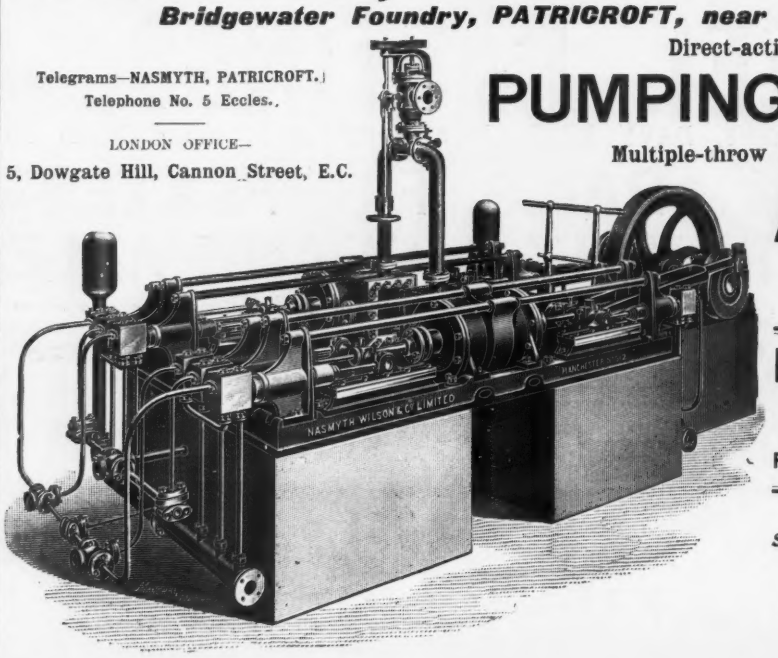
WELLMAN-SEAVER-MORGAN Co., Ld
47, VICTORIA STREET. Z373
See last and next week's issue.

NASMYTH, WILSON & CO., LTD.

Bridgewater Foundry, PATRICROFT, near MANCHESTER.

Telegrams—NASMYTH, PATRICROFT.
Telephone No. 5 Eccles.

LONDON OFFICE—
5, Dowgate Hill, Cannon Street, E.C.



Direct-acting Horizontal

PUMPING ENGINES.

Multiple-throw Belt or Gear-driven

Pumps

For COTTON Baling and other Presses.

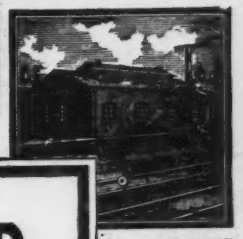
HYDRAULIC BALING & FINISHING PRESSES

For COTTON JUTE & other Fibre

MAKERS and ORIGINAL INVENTORS of
STEAM HAMMERS and STEAM PILE DRIVERS. Q438

TEAM STAMP HAMMERS,
DROP STAMP HAMMERS

CONSTRUCTIONAL IRON AND STEEL WORK OF ALL KINDS

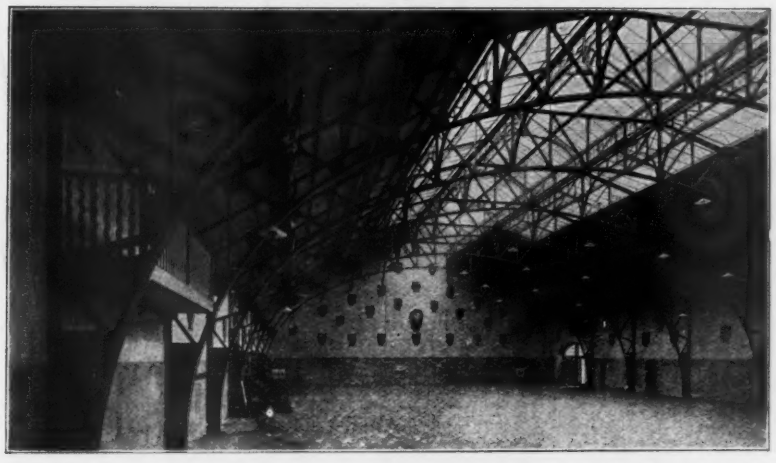


GALVANIZED CORRUGATED SHEETS, STAMPED GUTTERS.

TIMBER FRAMED GALVANIZED IRON BUILDINGS

JOHN LYSAGHT, LIMITED.

BRISTOL, NEWPORT (MON.), WOLVERHAMPTON, LONDON.



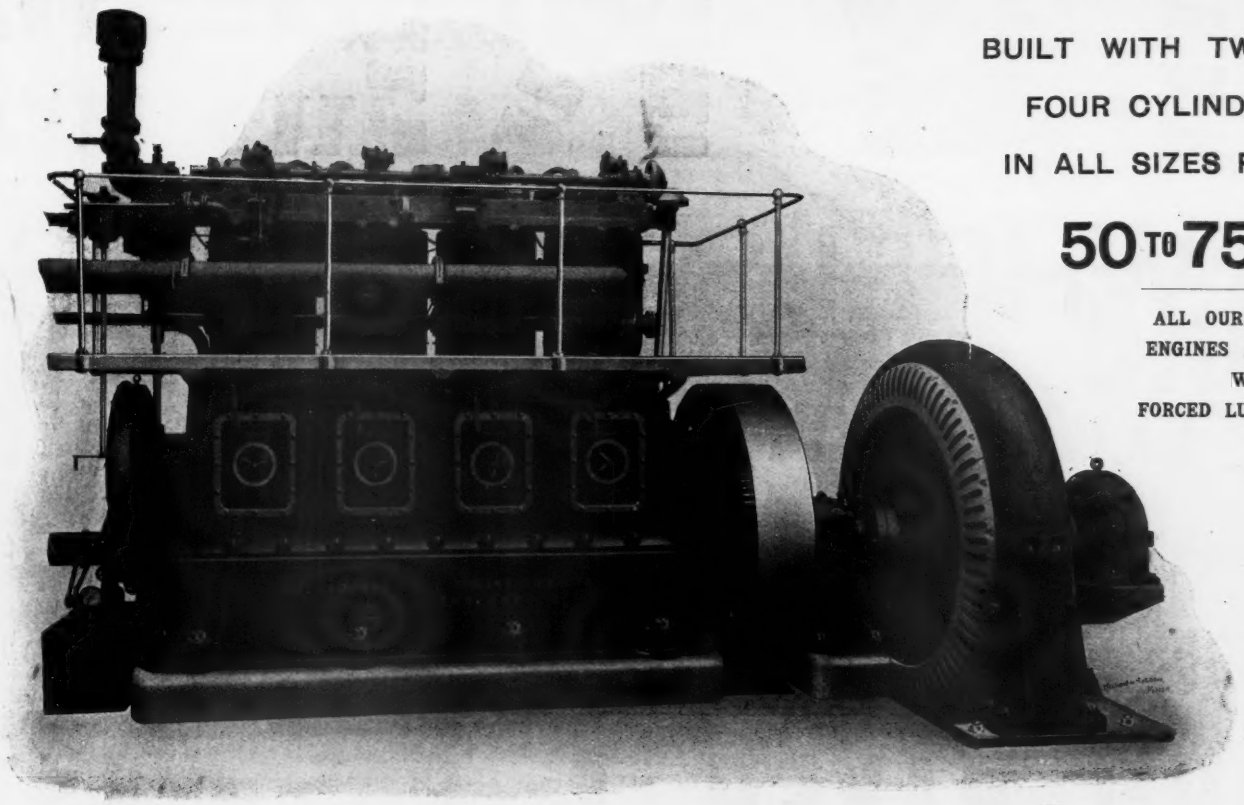
Drill Hall Roof Designed, Constructed and Erected by John Lysaght, Limited.

BRIDGES, GIRDERS, ROOFS, BUILDINGS.

Chief Offices—ST. VINCENT'S IRONWORKS, BRISTOL. 1700 London Office—35, GRACECHURCH ST., E.C.

IRON AND STEEL TANKS, CISTERNS, DOORS, SASHES, CHIMNEYS, PIPES.

"CAMPBELL" VERTICAL GAS ENGINES



BUILT WITH TWO OR FOUR CYLINDERS IN ALL SIZES FROM

50 TO 750 B.H.P.

ALL OUR VERTICAL ENGINES ARE FITTED WITH FORCED LUBRICATION.

FROM A PHOTOGRAPH OF A 360 B.H.P. ENGINE DIRECT-COUPLED TO ALTERNATOR. Q308

THE CAMPBELL GAS ENGINE CO., Ltd., Halifax, England.

Telegrams: "CAMGAS, HALIFAX." London Office: 114, TOOLEY STREET, S.E. Glasgow Office: 104, BATH STREET Telephone: No. 92 HALIFAX.

THE CHEAPEST POWER KNOWN.

SUCTION GAS POWER.

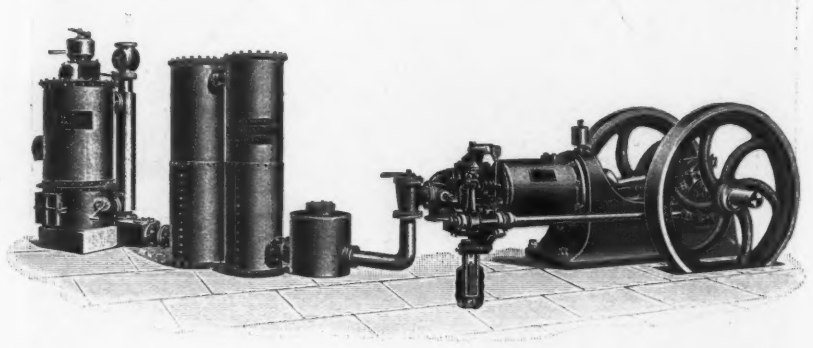
GOLD MEDAL AWARDED, PLYMOUTH.

Uses Anthracite Peas or Coke.

Guaranteed Consumption under 1 lb. per B.H.P. of anthracite per hour, or about One-tenth of a Penny per H.P. per Hour, or 10 H.P. for a Penny.

About One-third cost of town's Gas Driving.

Practically no attention required beyond refilling at intervals of several hours.



GAS ENGINES.

GAS PRODUCERS.

OIL ENGINES.

FIELDING & PLATT, LTD.,

GLOUCESTER.

Agents Wanted. **London Office: 118, Queen Victoria St., E.C.** A1830

TYRES

WHEELS & AXLES

FOR ALL TYPES OF

LOCOMOTIVES, CARRIAGES, WAGONS and TRAMCARS,

TO ANY SPECIFICATION.

JOHN BAKER & CO. (ROTHERHAM), LTD..

ROTHERHAM.

LONDON OFFICE: 8, Laurence Pountney Hill, E.C. Telephone 550 BANK Z15

We give a **FREE** trial of our "Klingerit" Jointing Material to all Steam Users who make application for it.

Send a paper template or drawing of the joint which is giving you trouble, and we will forward a

SAMPLE

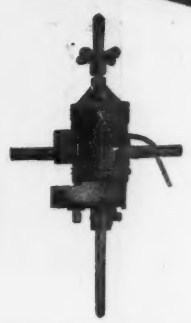
which will turn that trouble into triumph.

Ask for Pamphlet "K.C."

RICHARD KLINGER & CO.
ENGINEERS,
66, FENCHURCH ST., LONDON, E.C. 71, Exploration Bldgs., Johannesburg.
281, George St., Sydney, N.S.W.

PORTABLE ELECTRIC DRILLING MACHINES

Made in 12 sizes up to 2¼ capacity for continuous and alternating current.



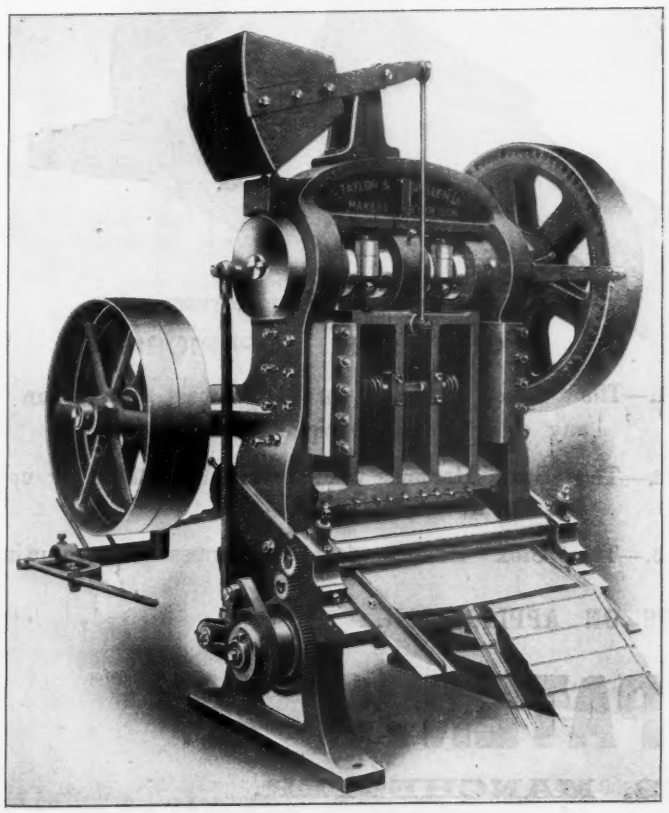
Completely encased, hence specially suited for outdoor work.

ASK FOR LIST B14a.

Z114

SCHUCHARDT & SCHUTTE,
Machine Tool Makers and Exporters,
34, VICTORIA STREET,
LONDON, S.W.

TAYLOR & CHALLEN, Ld.
ENGINEERS AND MAKERS OF
PRESSES
For the Manipulation of Sheet Metals, &c.



PRESS FOR PATENT ROOFING SHEETS.

About 100 Presses are usually in our Showrooms, many of which can be operated for intending purchasers

Q570

Constitution Hill, **BIRMINGHAM,** Eng.

THERMIT

Registered Trade Mark.

A FULLY-EQUIPPED

REPAIR SHOP

NOW OPEN

FOR

Repairs of every Description

AT

210A, BOW ROAD, LONDON, E.

ESTIMATES for WORK and ILLUSTRATED PAMPHLET FREE OF CHARGE upon application to

THERMIT LIMITED,

Telephone: 3749 CENTRAL.
Telegrams: "FULMEN, LONDON."

27, MARTINS LANE, CANNON STREET, E.C.

T118

STEAM CRANES & NAVVIES

.....

Locomotive Cranes.
(Steam and Electric).

Winches, Capstans, and Windlasses.

Concrete Mixers and Harbour Plant.

-.-.-

ILLUSTRATED CATALOGUE ON APPLICATION.

-.-.-

JUBILEE STEAM CRANE NAVVY (Simpson & Porter's Patent).
Has excavated and filled into wagons 2160 cubic yards of hard gravel in 11 hours.

Gives largest output of any excavator or steam navvy. Least coal consumption and maintenance. Will work a 22ft. face. Will drive a gullet 50ft. wide. Will revolve an entire circle. Will deal readily with boulder clay and hard material. The digging gear can be disconnected by drawing two cotters, the machine then becomes a 12-ton ordinary loco. crane. **USED BY ALL THE PRINCIPAL CONTRACTORS.**

12 Tons size in stock or progress. **Weight about 40 tons.**

FULL PARTICULARS ON APPLICATION.

JOHN H. WILSON & Co., LIMITED,

(Removed from SANDHILLS, LIVERPOOL),

NEW WORKS AND OFFICES: ***DOCK ROAD, BIRKENHEAD.***

LONDON OFFICES - 15, VICTORIA STREET, WESTMINSTER.

Y835

—STOX—

THE LAST WORD IN

PNEUMATIC HAMMERS.

RIVETING, CHIPPING AND CAULKING.

By adopting an entirely new system of applying and utilising the power supplied, vibration has been eliminated from the "Stox" Hammers.

BRITISH MANUFACTURE.

POINTS OF SUPERIORITY

1.—The "Stox" Hammers **cost 30 per cent. less** to run than any other make for equal working capacities.

2.—The "Stox" Hammer **costs** practically **nothing** for upkeep and repair.

3.—The "Stox" Hammer **does not distress workmen** using it

PRICES AND PARTICULARS ON APPLICATION.

THE CLIMAX PATENTS LD.

42, SPRING GARDENS, MANCHESTER.

AGENTS:

SCOTLAND—
ALEXANDER CRAIG,
124, St. Vincent Street,
Glasgow.

LONDON—
Messrs. CUNNINGHAM and MORRISON, Moorgate Court,
Moorgate Place, E.C.

NEWCASTLE-ON-TYNE—
CROSIER, STEPHENS & CO.,
2, Collingwood Street,
Newcastle-on-Tyne

FRANCE—
Monsieur PIERRE PORTE.
30, Rue des Colones du Trône
Paris

HARTNESS

CHUCKING LATHE

stands for efficiency and the highest standard of modern manufacturing.

THE ABSOLUTE CONTROL of TOOLS

Their stability and the ease with which they can be adjusted means much to the operator, and counts largely in the quality and quantity of output.

THE LUBRICATING SYSTEM

is practical and efficient.

THIS LATHE

cannot be equalled by any other machine.

ALL GEARS

and running surfaces are protected from the dust of cast iron, so that steel as well as cast iron may be used.

UNIQUE FEATURES

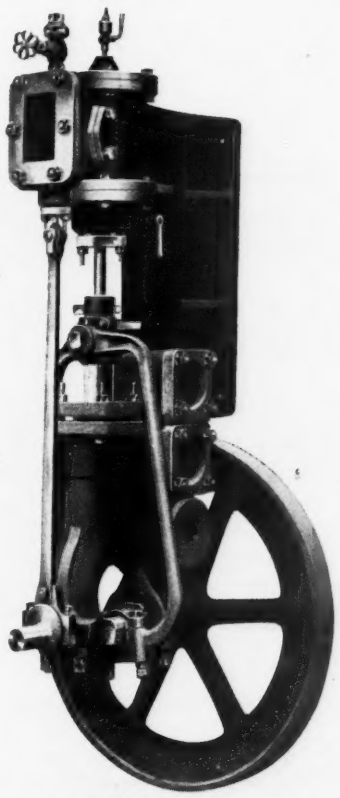
are the cross sliding head, single drive, and variable speed device.

JONES & LAMSON MACHINE CO., 97, Queen Victoria Street, LONDON, E.C. D21

Telegrams—TURRETORUM, LONDON. Depot for Scotland—129, TRONGATE, GLASGOW Telephone—824 BANK, LONDON.

(Copyright).

THE MANCHESTER DONKEY OR WALL PUMP

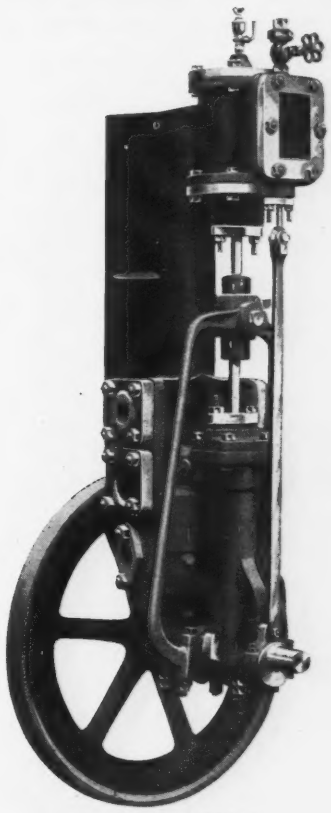


SINGLE-ACTING

THE
BEST
DONKEY PUMP
IN THE
WORLD.

CATALOGUES ON APPLICATION.

Telegrams—PUMPS, MANCHESTER.
Telephone—1021



DOUBLE-ACTING

FRANK PEARN & CO., LTD., MANCHESTER, S.E.

GLASGOW—
P. & W. MACLELLAN, Ltd., Trongate.

LONDON—
49, Queen Victoria Street, E.C.

NEWCASTLE-ON-TYNE— U184
REES & WILSON, High Bridge.

BROADBENT'S

Electric Overhead Cranes,

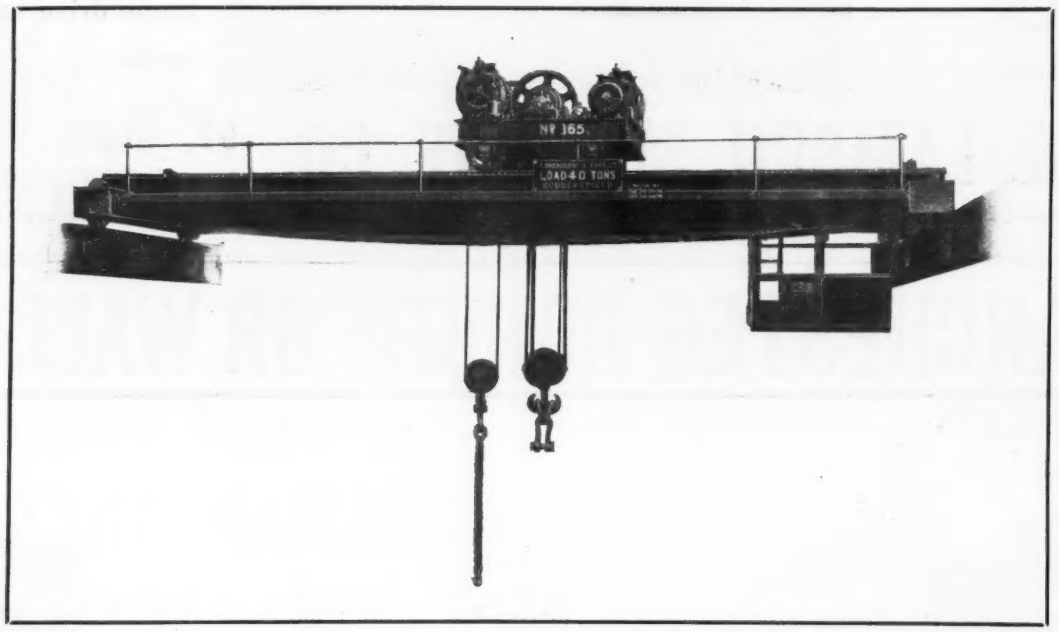
Electric Jib Cranes,

Electric Capstans,

Electric Winches & Hauling Gear,

&c. &c.

Telegrams: BROADBENT, HUDDERSFIELD. Telephones Nos. 102 & 1001, HUDDERSFIELD.



SEND FOR OUR NEW SIXTY-PAGE CATALOGUE.

THOMAS BROADBENT & SONS, LTD.,

Central Iron Works,

HUDDERSFIELD.

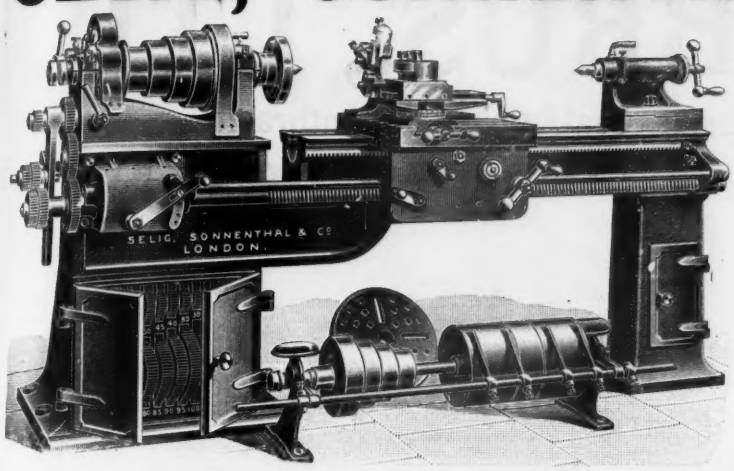
LONDON OFFICE: SUFFOLK HOUSE, LAURENCE POUNTNEY HILL, E.C. Telegrams: Syphonia, London

GLASGOW OFFICE: 74, YORK STREET, GLASGOW. " Target, Glasgow.

NEWCASTLE OFFICE: 13, MOSLEY STREET, NEWCASTLE-ON-TYNE. " Cranes, Newcastle-on-Tyne.

B25

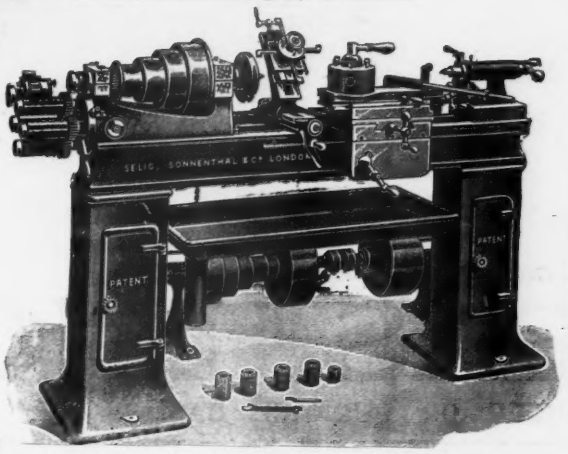
SELIG, SONNENTHAL & CO.,



Sole Makers of
THE
"NATIONAL"
IMPROVED
Self-acting Slide
Surfacing,
AND
Screw-cutting
LATHE.

THE PATENT
UNIVERSAL
MONITOR
Brass-Finishers'
LATHE.

Four different pitches of thread instantly available without change of any kind.

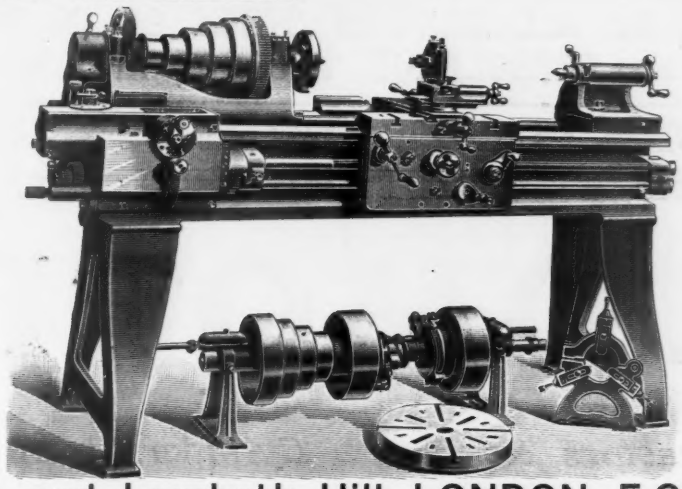


AS SUPPLIED TO:—

H M Dockyards (two machines, one repeat order).
Messrs. Fodens, Ltd.
Messrs. Commercial Cars, Ltd.
Mr. C. H Bailey (two machines).
Messrs. Davey, Paxman and Co., Ltd.
Messrs. Pulsometer Eng Co., Ltd., (two machines, one repeat order).
Messrs. S. Dixon and Sons, Ltd.
Messrs. Wm. Sugg and Co., Ltd.
Messrs. Elliott and Garrood.
Messrs Walker Bros., Ltd.
Messrs. Lindsay, Carverhill and Co.
&c. &c.

THE "PEERLESS"
IMPROVED
SCREW-CUTTING
LATHE,
WITH PATENTED
INSTANTANEOUS CHANGE
GEAR.

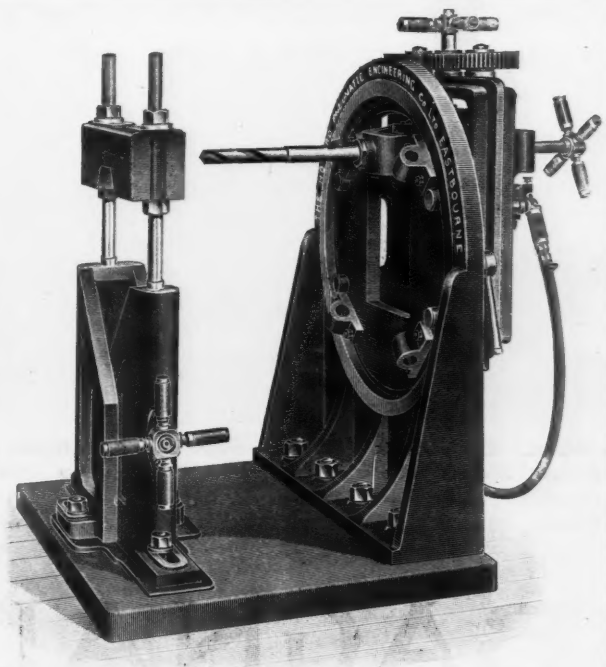
T132



85, Queen Victoria St. and Lambeth Hill, LONDON, E.C.

PNEUMATIC RADIAL PIPE FLANGE DRILL.

The Machine is constructed for Drilling Bolt Holes in Pipe Flanges. The pipe is gripped centrally and the correct radius and spacing of any number of holes is obtained by means of graduated scales on the machine without marking off.



CONTRACTORS TO THE ADMIRALTY, WAR OFFICE, AND INDIA OFFICE.

MANUFACTURED BY

THE HOWARD PNEUMATIC ENGINEERING CO., LD.,
EASTBOURNE, ENGLAND.

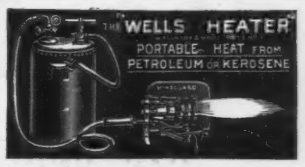
Q132

THE "WELLS LIGHT"
WALLWORK & WELLS PATENTS

Horizontal Flame unaffected by weather.

No. 0.—500 Candles, small hand pattern	£7 7 0
No. 1.—500 or 1500 Candles, hand pattern, with No. 2 size burner, for Tar Oil	£10 0 0
No. 2.—1500 Candles, useful and portable pattern	£15 10 0
No. 3.—2500 Candles, Manchester Ship Canal pattern	£16 10 0
No. 4.—3500 Candles. A most powerful lamp	£17 15 0

Arranged to burn Kerosene or Petroleum in Foreign Countries; in Great Britain our Special Wells Oil is used, which is half the price and gives 30 per cent. more light.



Applied instantly to all classes of work for
TYRE EXPANDING, BENDING, STRAIGHTENING, SETTING, SHRINKING, &c.

PRICES:

No. 0.—A small size complete with burner for use where great portability is an advantage	£10 0 0
No. 3.—With Oil Tank, Air Pump, Burner and all Fittings, complete	£19 15 0
Heater Burner and Hose only	£5 0 0

All the following Sole Agents hold stocks for immediate delivery, and where the WELLS LIGHT can be seen, tested, and every information obtained.

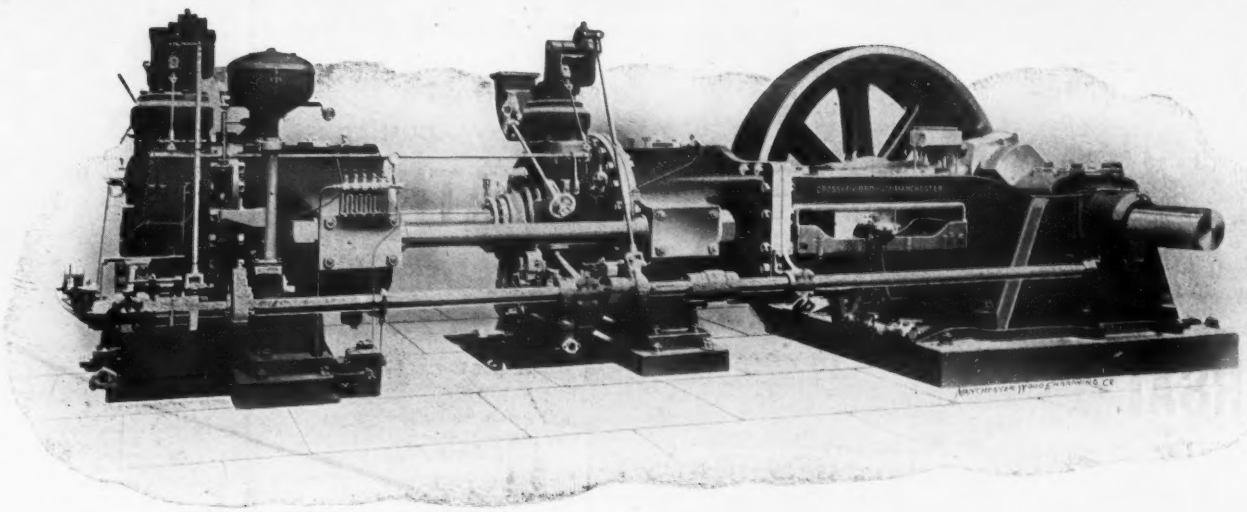
GLASGOW—JAMES T. DONALD & CO., Ltd., 35, McAlpine Street.
DUNDEE—T. C. KEAY, Baltic Street.
NEWCASTLE-ON-TYNE—EMLEY & SONS, Ltd., Westgate Road.
LIVERPOOL—EVERETT & CO., 40, Chapel Street.
N. W. COUNTIES—ISAAC BRAITHWAITE & SONS, Kendal
BIRMINGHAM—RICHARD LLOYD & CO., Steelhouse Lane.
SHEFFIELD—TASKER'S ENGINEERING COMPANY, Blonk Street.
BELFAST—ROBERT PATTERSON & SONS, Bridge Street.
DUBLIN—BOOTH BROTHERS, Upper Stephen Street.
SOUTH-EASTERN COUNTIES—W. H. WILLCOX & CO., Ltd., 23, Southwark Street, London.
HOLLAND—WYNMALEN & HAUSMANN, Rotterdam.
RUSSIA—The J. BLOCK CO., Moscow, St. Petersburg, Odessa, Warsaw, Kief, Rostoff, Ekaterinburg, Kokand, &c.
FRANCE—ROFFO & CIE., 8, Place Voltaire, Paris.
ITALY—ING. VITTORIO CROIZAT, Via Gioberti 13, Turin.
NORWAY—S. H. LUNDH & CO., Christiania.
SWEDEN—GEO. MATTHIESENS, Maskinaffar, Gothenburg.
FINLAND—AXEL von KNORRING'S TEKNISKA BYRA, Helsingfors.
SOUTH AFRICA—DURBAN: JENKINS & CO.; **CAPE TOWN:** GEO. FINDLAY & CO.
NEW ZEALAND—E. W. MILLS & CO., Ltd., Wellington; R. B. DENNISTON & CO., Dunedin.
WESTERN AUSTRALIA—J. & W. BATEMAN, Freemantle.
INDIA (Province of Bengal)—T. E. THOMSON & CO., Ltd., 9, Esplanade East, Calcutta.
JAPAN—TAKATA & CO., Tokio, Osaka, Yokohama.
UNITED STATES—The WELLS LIGHT MFG. CO., Licensed Manufacturers, 46, Washington Street, New York.

A. C. WELLS & CO., 101, Midland Rd., St. Pancras, **LONDON.**
Works: Carnarvon St., Manchester.

CROSSLEY BROS., LTD.

GAS PLANTS for Bituminous Coal, Coke, or Anthracite.

AMMONIA RECOVERY PLANT. **GAS WASHING PLANT.**



CROSSLEY'S DOUBLE-CYLINDER SINGLE-ACTING

500 H.P. GAS ENGINE

FOR PRODUCER OR FURNACE GAS.

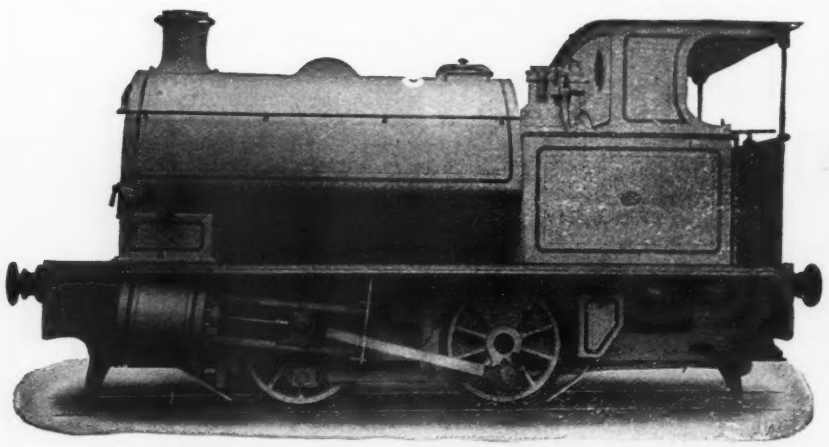
GAS ENGINES OF ALL SIZES IN STOCK OR IN PROGRESS.
PETROL, OIL, ALCOHOL AND MARINE ENGINES.

OPENSHAW, MANCHESTER. L361

LOCOMOTIVES

For Contractors, &c. *Cylinders from 4 to 16-inch.*

NEW CATALOGUE
16th EDITION
NOW READY.



PORTABLE RAILWAYS

WAGONS
OF ALL DESCRIPTIONS.

14in. x 20in. In stock and progress. 4ft. 8½in. gauge.
9in. x 14in. For quick delivery. Gauge to suit requirements.
7in. x 12in. " " " " " " "
6in. x 9in. " " " " " " "

W. G. BAGNALL. LTD.,

STAFFORD.

Codes Used—"Engineering," "A B C," & "Bedford McNeills." Y563 Telephone No. 15. Telegrams—BAGNALL, STAFFORD.

"SENTINEL" Compound Intercooling AIR COMPRESSORS.

(Belt, Steam, Motor, and Gas Engine-Driven.)

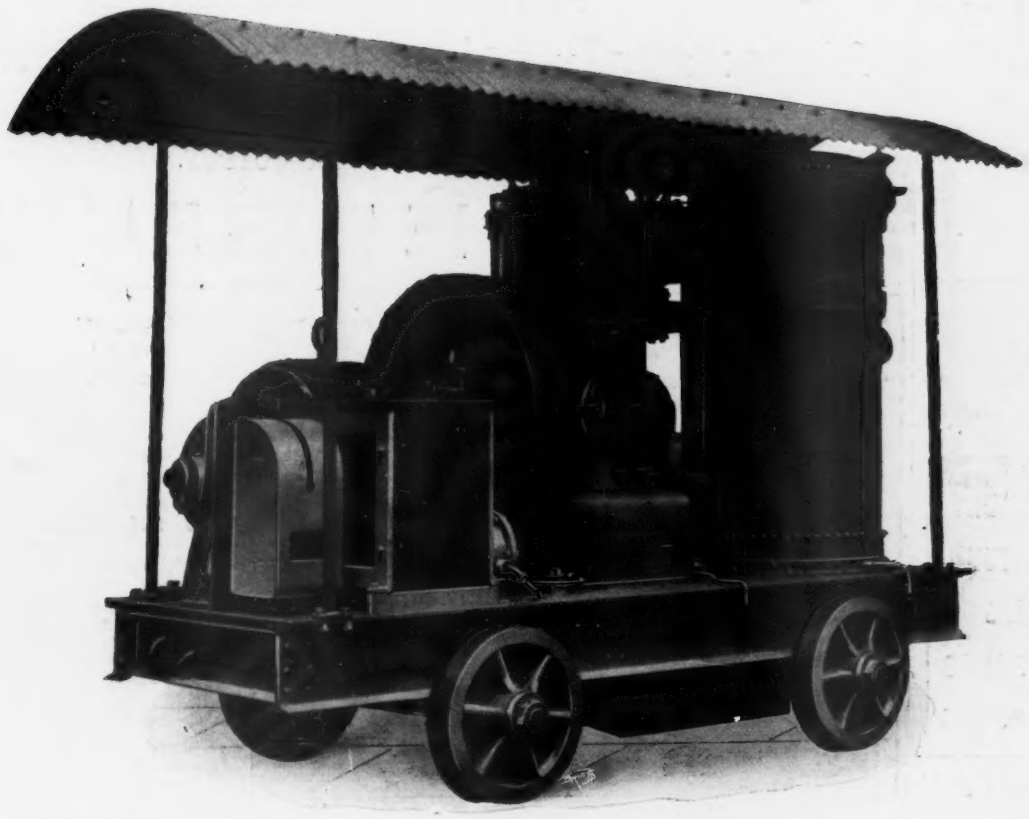


Photo of PORTABLE MOTOR-DRIVEN AIR COMPRESSOR supplied to the Fairfield Shipbuilding and Engineering Co., Ltd., Govan, for use in Shipyard Slips.

The above Plant, being enclosed, is protected from possibility of damage or unfitness for use through bad weather. It is of very strong construction, and will stand robust handling. The ease with which it can be transported from place to place makes it an eminently suitable plant for yard and slip use.

ALLEY & MACLELLAN,

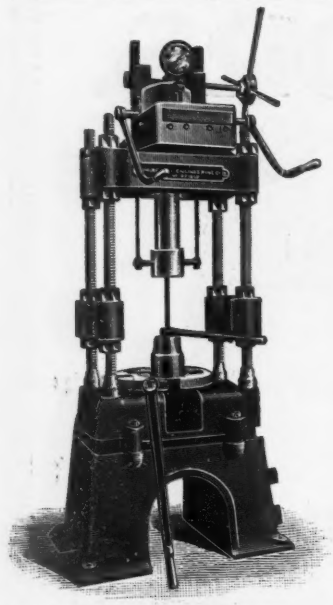
Q516 LTD.,

SENTINEL WORKS, GLASGOW.

D

MANDRIL, BROACHING, BUSHING,

SHAFT STRAIGHTENING &
ENGINEERS' UTILITY PRESS.
(HYDRAULIC)
An Excellent Tool for Engineering Work.



MIRFIELD ENGINEERING CO., Ltd.
MIRFIELD. Z185

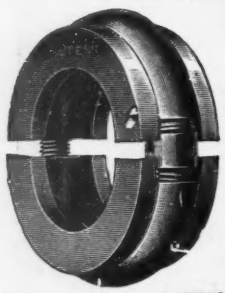
AIR COMPRESSORS
VACUUM PUMPS
AIR PUMPS

Steam, Belt, or Motor Driven Pumps

F. W. BRACKETT & CO.
HYTHE BRIDGE IRONWORKS, COLCHESTER.

'DRY' VACUUM PUMPS
DONKEY PUMPS
3-THROW PUMPS
Z117

"SPLIT GRIP"
COLLAR (TRIER'S PATENT)



As USEFUL as the SPLIT PULLEY

IN HALVES.

NO Set Screw to cause Accidents

Grips like a Vice.

Fixed or Removed without Disturbance.
H501

Sole Makers,
TRIER Bros.
1, Great George Street, WESTMINSTER, LONDON.

HIGH-CLASS CASTINGS.
Electric & Gas Lamp Pillars.
FEEDER PILLARS and MANHOLES.
SANDWASHERS.
GAS, OIL, AND VACUUM ENGINES
HARDY & PADMORE, Ld., Worcester
Larger advertisement first issue in each month Q515

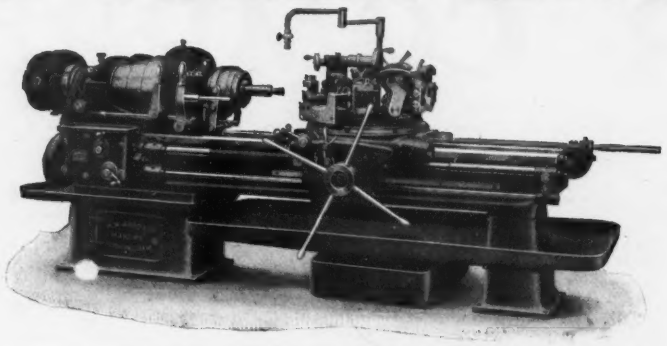
JOSHUA HEAP & CO.,
ASHTON-UNDER-LYNE. Ld.
PIPE SCREWING MACHINES,
Up to 12in.
BOLT SCREWING & NUT TAPPING MACHINES,
Up to 4in.
CATALOGUE ON REQUEST. Q529
See larger advertisement alternating with this.

HALL'S SPECIAL PUMPS
Compound direct-acting. Single-cylinder direct-acting
For Boiler Feeding, Light Service, General Purposes.
ECONOMICAL AND EFFICIENT. Q544
J. P. HALL & SONS, Limited,
Engineers, PETERBOROUGH.
See larger Advt. last and next week

H. W. WARD & CO., LIONEL STREET, BIRMINGHAM.

BRITISH
FLAT TURRET LATHES.

LATEST PATTERN ROLLER STEADIES.



FRICTION GEARED HEADSTOCK.

THE PREMIER BRITISH FLAT TURRET LATHE.

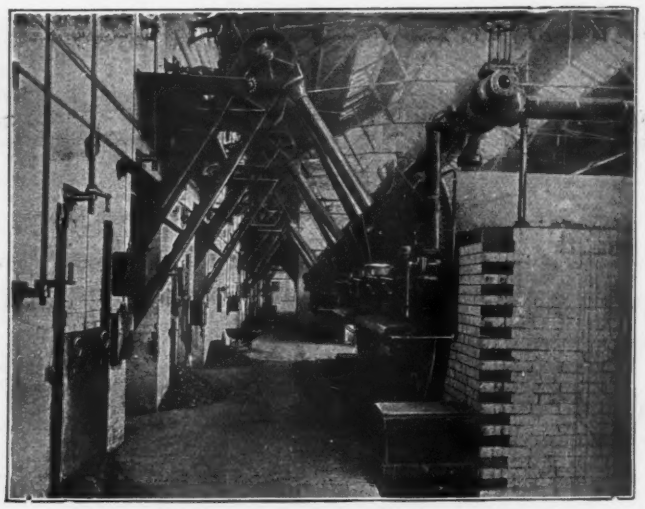
Sizes: 2¼in. x 30in., 3½in. x 42in., 5in. x 48in.

OUR LATEST PATTERN ROLLER STEADIES WILL MORE THAN DOUBLE YOUR OUTPUT.

Q327
A BAR LATHE FOR BAR WORK.

BENNIS
BOILER-HOUSE PLANT

INCLUDES
BENNIS STOKERS AND COMPRESSED AIR FURNACES,
BENNIS ELEVATORS AND CONVEYORS.



BENNIS Mechanical Stokers and Coal Elevators in Boiler-house of Coventry Corporation Electricity Works.

BENNIS
Stokers & Compressed Air Furnaces are applicable to one boiler or many; to Lancashire or Water-tube.

BENNIS
Chain-Grate Stokers (Bennis-Miller-Bennett patents) are without dumping bars, have halved links, and an adjustable air supply.

BENNIS
Elevators & Conveyors mean economic transport from first delivery to final deposit.

BENNIS PLANT
ENSURES
(1) Cheap Steam,
(2) Low Fuel Costs,
(3) Highest Evaporative Duty,
(4) Smokelessness,
(5) Minimum Costs of Transport, and
General Economic Success

BENNIS GUARANTEES the Buyers SPECIFIC RESULTS.

ED. BENNIS & CO., Ld., Little Hulton, BOLTON.
London Office: 28, VICTORIA STREET, S.W. X1669

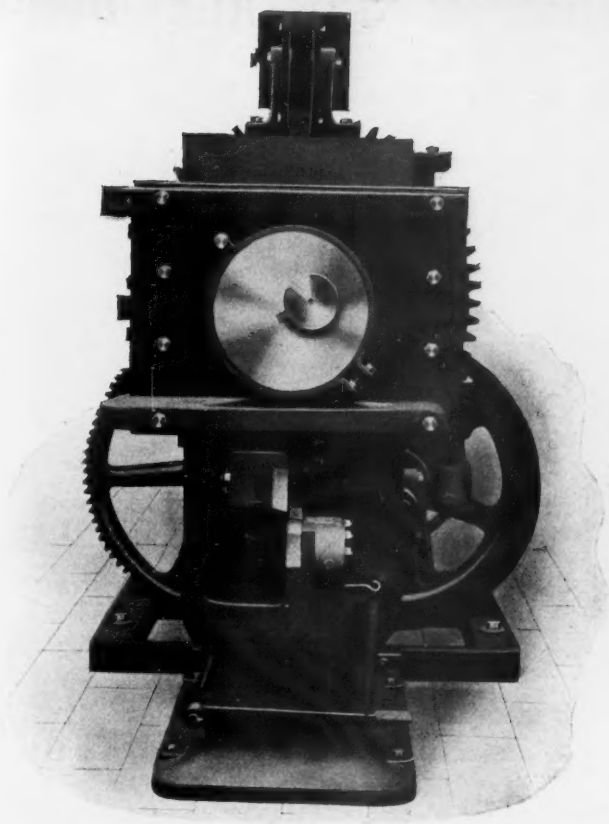
THE MOTHERWELL BRIDGE CO., LD.
Telegraphic Address—"BRIDGE." MOTHERWELL, N.B. National Telephone—No. 40

BRIDGES, ROOFS,
PIERS, TANKS.

DOCK GATES
AND SIMILAR
STRUCTURAL WORK.

HYDRAULIC PRESSED FLOORING a SPECIALITY

IN STOCK.



IMMEDIATE DELIVERY.

POWERFUL BAR SHEARS

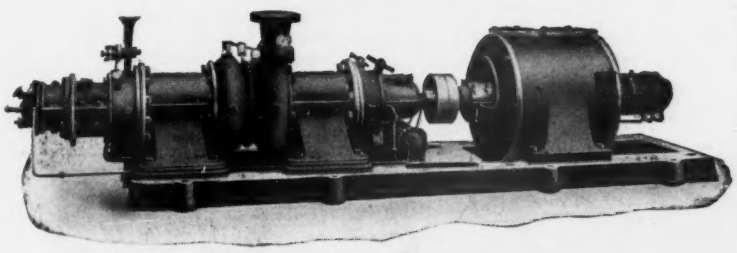
as above. Cuts mild steel bars up to 2in. thick cold, or plates in proportion, with great ease; blades 12in. long.

J. RHODES & SONS, LTD.,

Grove Ironworks, Wakefield, Yorks. Q498

GELPKE & KUGEL'S PATENT

TURBO-HIGH-PRESSURE PUMPS.



Highest Efficiency. Smallest Cost of Installation.
Greatest Certainty of Operation. Smallest Space Required.

FOR ALL HEADS AND CAPACITIES.
ADAPTED TO PURE AND IMPURE LIQUIDS.

SOLE MAKERS FOR GREAT BRITAIN AND COLONIES UNDER LICENCE FROM:

ESCHER WYSS & CO., ZURICH.

HAYWARD-TYLER & CO.,

LIMITED,
HYDRAULIC, ELECTRICAL, & SANITARY ENGINEERS,
99, QUEEN VICTORIA STREET, LONDON, E.C.
Telegrams—TYLEROX, LONDON. Telephones—702 & 199 BANK. R139.

Holden & Brooke, Ld.

Sirius Works, West Gorton, Manchester.

THE
"Expulsor" Pump.
(Brooke's Patent)

For raising large quantities of liquid with a minimum of plant or preparation.

The **EXPULSOR PUMP** will be found the best all-round **out-of-door** pump.

Always ready to work, no working parts, no derangement.

The pump that costs least to buy, least in steam when at work, and least in upkeep.

Send for List 82 A.

Brooke's (Patent) Steam Dryers

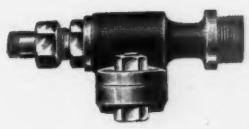
The only system in which the method of **extraction** is **theoretically correct**, the moisture being extracted without breaking up the steam or disturbing its flow.

Important.—Rivetted bodies having proved unreliable, ours is the **only really suitable construction**, especially for high pressures and superheated steam.

They are used in the leading electric light stations, and in the power plants of the largest manufacturing concerns in Great Britain.

Send for List 140 A.

Ejectors and Water Lifters.



For economically raising and forcing water, sludge, bilge, and other liquids, extracting air and gases.

Send for List 105 A.

THE
"Sirius" Steam Trap.

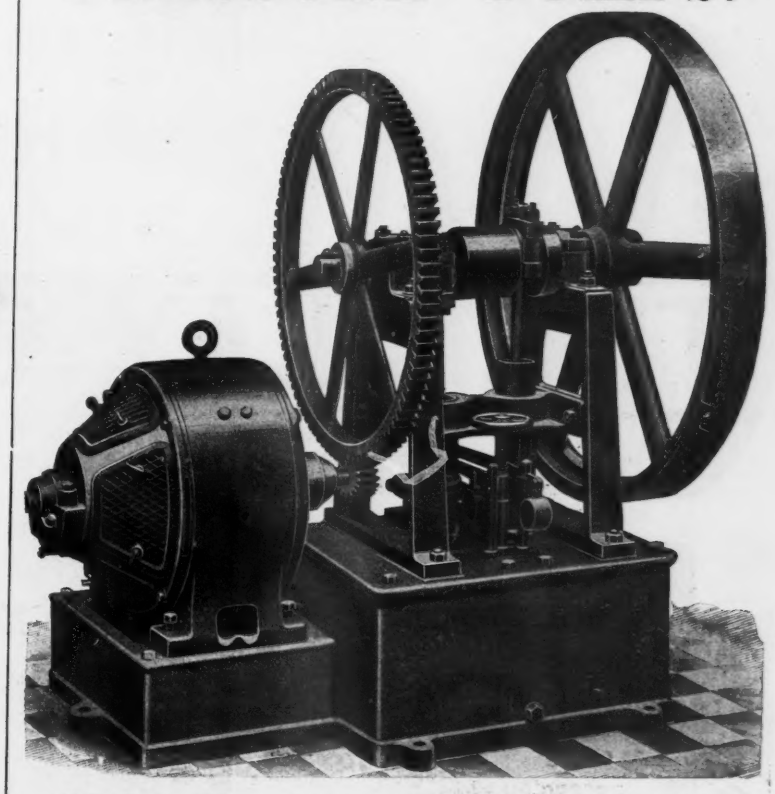
There are many Sirius-like Traps. There is only one "Sirius" Trap—Reg. Trade Mark "Sirius" cast on cover of each Trap, and is a guarantee of quality.

The **"SIRIUS" TRAP** is the **only one** of its class **British made**, and the high quality upon which its reputation has been made is equally maintained to-day.

Send for List 103 A.

MOTOR-DRIVEN

PRESSURE PUMPS.



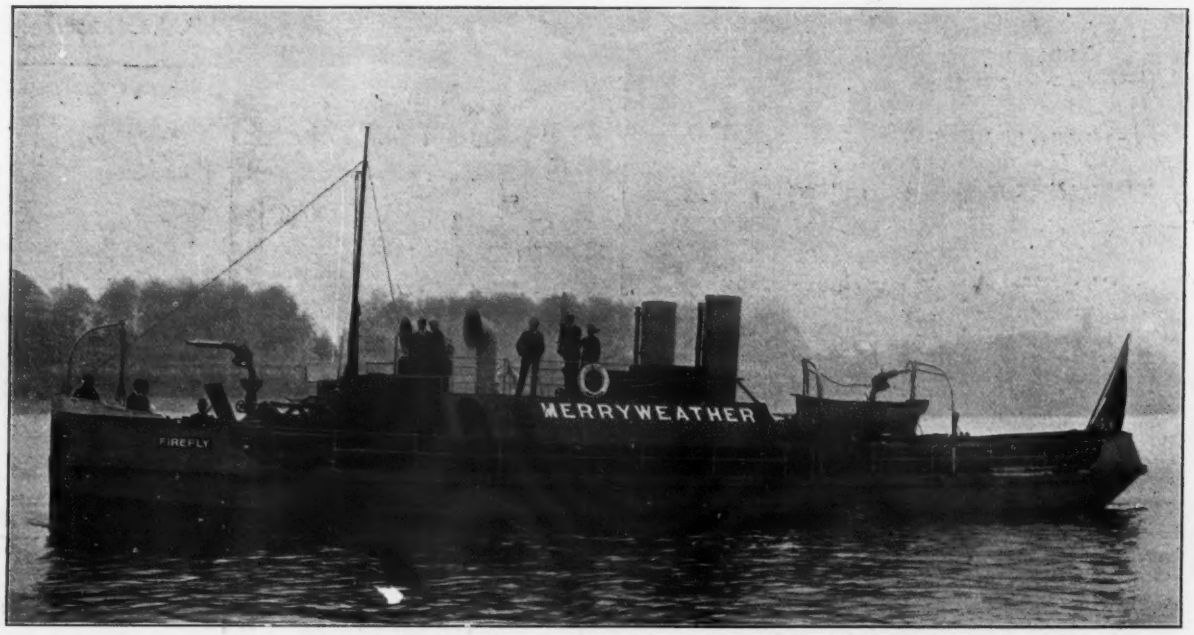
HOLT & WILLETTS,

T118

Cradley Heath,
AND
6, LLOYD'S AVENUE, LONDON, E.C.

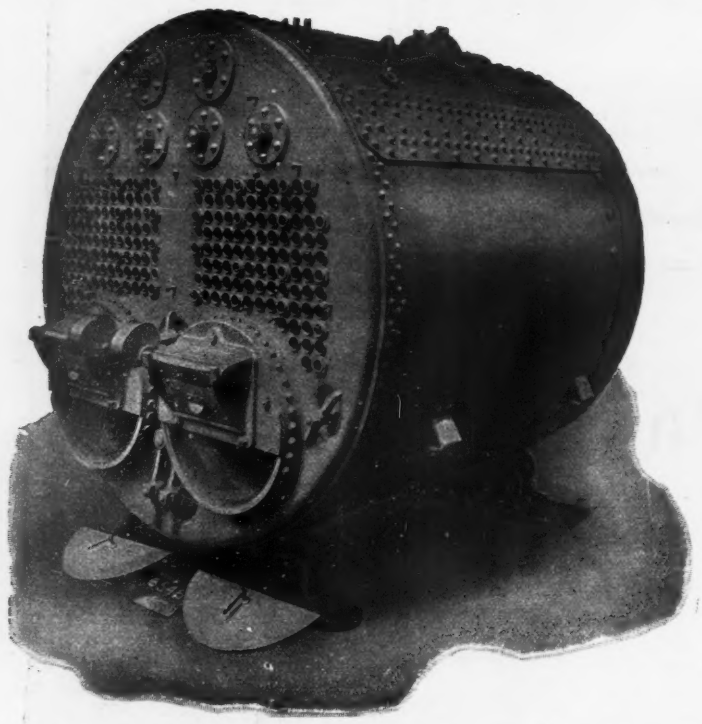
MERRYWEATHERS' SEA-GOING FIRE & SALVAGE BOAT

FOR MANCHESTER SHIP CANAL.



Length, 90ft.; Beam, 23ft.; Speed, 8 knots. Pumping Capacity for Fire Duty, 4000 gallons per minute; for Salvage, 5000 gallons per minute. Twin-screw Compound Propelling Engines.
Cabin for Crew and Hose Store. BOATS DESIGNED & BUILT TO SUIT SPECIAL REQUIREMENTS. Ask for Illustrated Catalogue 588 L.E. Y807

MERRYWEATHER & SONS, GREENWICH, S.E. LONDON.



Telegraphic Address—ABBOTT NEWARK. National Telephone—No. 34

For High-Class

BOILERS

OF ALL TYPES
AND FOR ALL PRESSURES,

APPLY TO

ABBOTT & CO. (NEWARK) LD.

NEWARK-ON-TRENT.

CONTRACTORS TO THE ADMIRALTY, WAR OFFICE, INDIA OFFICE, BOARD OF CUSTOMS, CROWN AGENTS, etc. etc.

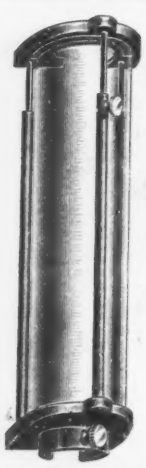
FLANGED & WELDED WORK every description.
MOTOR VAN BOILERS.
HYDRO' CASINGS.
REPAIR FIRE-BOXES.
EVAPORATOR SHELLS.
AIR RECEIVERS, &c.

ABC CODE. O569

THE CLAY CROSS CO.

Manufacturers of Pig Iron, Gas and Water Pipes, Fuel Economisers, Tanks, Columns, Stanchions, and Castings for Gas, Water, and Sewerage Works, Collieries, Engines, Pumps, &c.

Works— Clay Cross, nr. Chesterfield **LONDON OFFICE: 19. EASTCHEAP, E.C.** Telegrams— JACKSON, CLAYCROSS. O15J



Circular Pattern.

PATENT TELESCOPIC GAUGE GLASS PROTECTORS.

Square Pattern.

J. TOMEY & SONS, LTD.

"EUREKA"

Established 1853.

GAUGE GLASSES

Telegraphic Address— "TOMEY ASTON," BIRMINGHAM.

Supplied for nearly half a century to the principal Railway and Steamship Companies and Engineering Firms of the world, and adopted in His Majesty's and principal Foreign Navies of the world.

Also Patentees and Makers of the **Enamelled and Red Stripe Gauge Glasses and the New S.H.P. Gauge Glass, and Glass Tubing of every description.**

Head Offices— CATHERINE STREET, ASTON, BIRMINGHAM.

LONDON WAREHOUSE & SHOWROOMS: -93, HATTON GARDEN, E.C. W1896

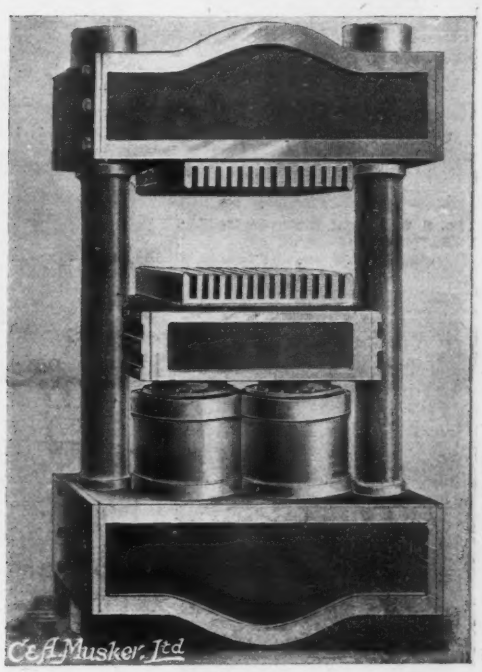
C. & A. MUSKER, LTD.

COMPOUND SURFACE CONDENSING PUMPING ENGINES.

Hydraulic and Electric Engineers,

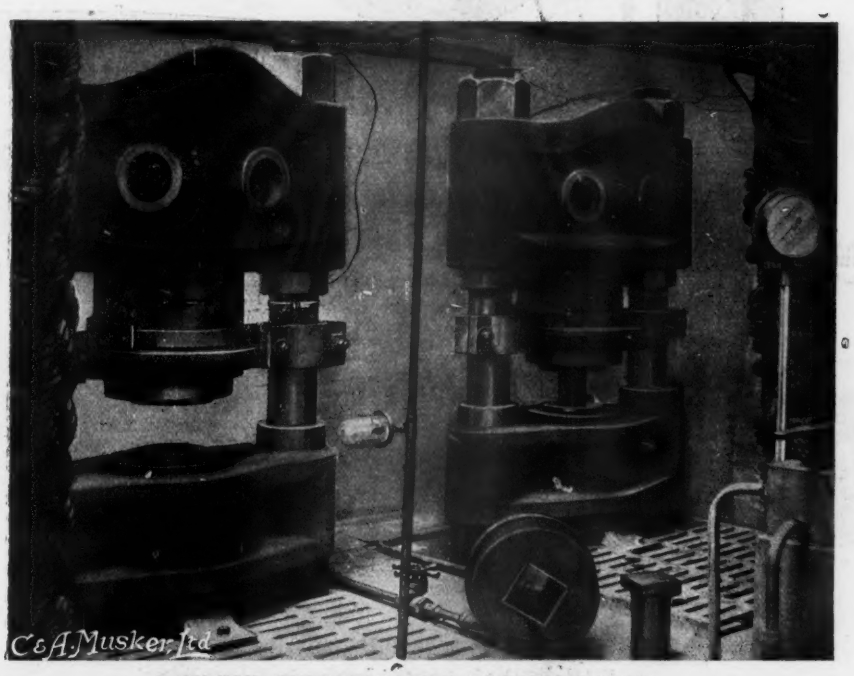
LIVERPOOL.

AIR COMPRESSORS.
VACUUM PUMPS.



1140-TON HYDRAULIC FINISHING PRESS.

ELECTRIC CRANES.
LIFTS AND PUMPS.
FORGE HAMMERS.
HYDRAULIC MACHINE TOOLS.



600 TON HYDRAULIC GUN COTTON PRESSES.

HYDRAULIC LIFTING, PRESSING, AND PUMPING MACHINERY.

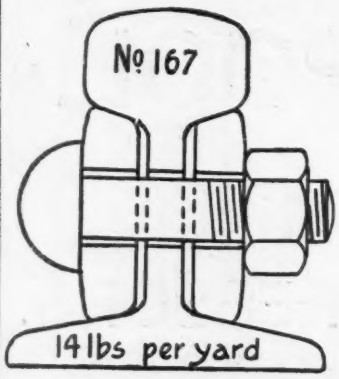
R. HUDSON, GILDERSOME FOUNDRY NEAR LEEDS.

London Offices: { BROAD STREET HOUSE, NEW BROAD STREET, E.C.

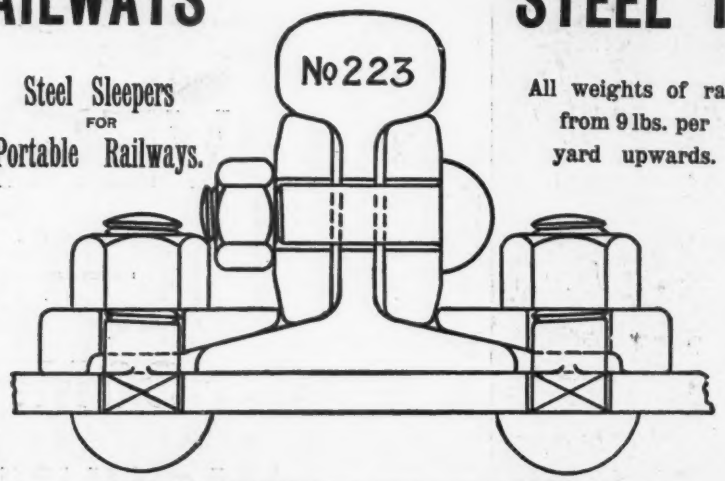
Telegrams— FOUNDRY, GILDERSOME. INGENIOSO, LONDON.

Telephones— 14 LEEDS. 5533 P.O. CENTRAL.

PORTABLE RAILWAYS

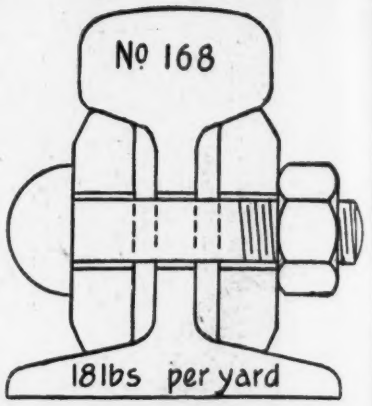


Steel Sleepers FOR Portable Railways.



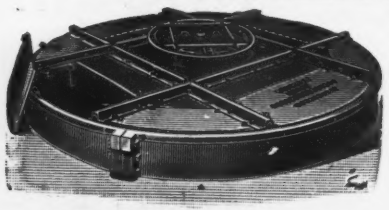
STEEL TIPPING WAGONS

All weights of rail from 9 lbs. per yard upwards.



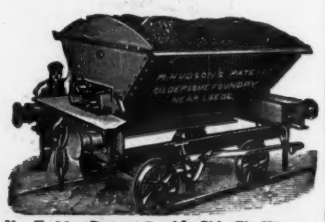
STEEL TROUGH OR CORRUGATED SLEEPER, WITH BOLTED CLIPS.

No. E. 96—Patent Double Centre Steel Side Tip Wagon (Diamond Fields Pattern), with jockey for wire rope haulage.

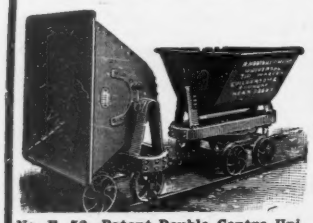


No. E. 115—Self-contained Turntable.

No. E. 11—Right and Left-hand Three-way Steel Point and Crossing.



No. E. 59.—Patent Double Side Tip Wagon. To work with ordinary Railway Wagons made to any size. Can be tipped by one man.

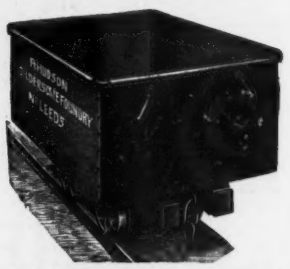


No. E. 50—Patent Double Centre Universal Tip Wagon, tipping either Endways or Sideways at will.

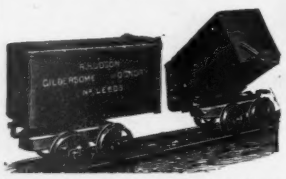
No. E. 1—Patent Steel End Tip Wagon

No. E. 22—Two Tons Steel Plate Bogie. "Practically Indestructible." Always in Stock. Platform about 56in. long by 30in. wide. Height 23in. Weight about 4 cwts. 18in. Steel Wheels.

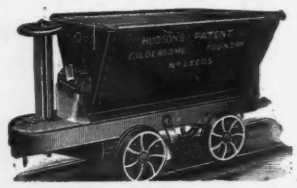
No. E. 76—Hand Trolley, made to carry any weight, or to suit any rail gauge.



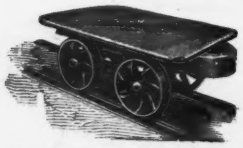
No. E. 101—Steel Plate Colliery Truck.



No. E. 97—Steel Side and End Tip Wagon, with Flapping Door (for hand use).

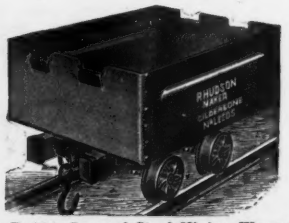


No. E. 162—Patent Steel Double Side Tip Wagon, with screw brake and platform.

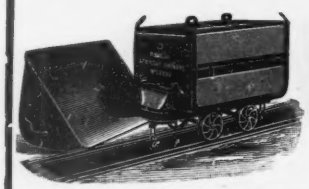


No. E. 58—Steel Plate Bogie.

No. E. 86—Steel Tip Buckets.



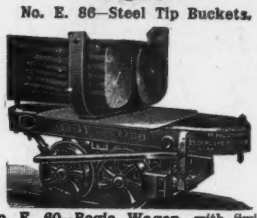
No. E. 104—Pressed Steel Mining Wagon.



No. E. 193—Crane Brick Box to fit on standard side tip wagon underframe.

No. E. 171—Coke-charging Barrow, with end door.

No. E 15—Steel Cage. With Safety Grippers and Fallers complete.



No. E. 60—Bogie Wagon, with Swivel Fork, for carrying long baulks.

No. E. 106—Steel Hopper Wagon, with sliding door worked by lever.

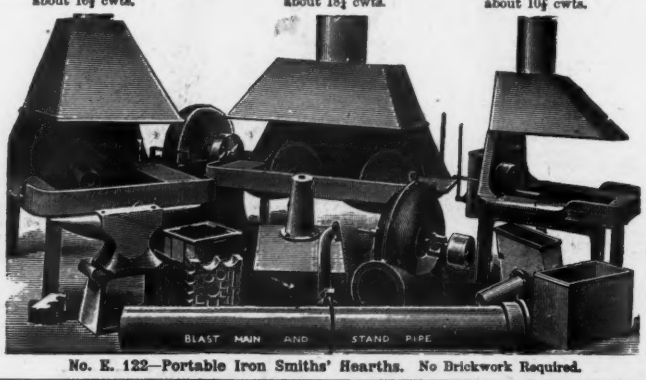
"A GREAT SUCCESS."

No. E. 16—Patent Steel Barrows. Practically Indestructible.

5ft. × 5ft. HEARTH, about 16½ cwts.

DOUBLE HEARTH, about 18½ cwts.

3½ft. × 4ft. HEARTH, about 10½ cwts.

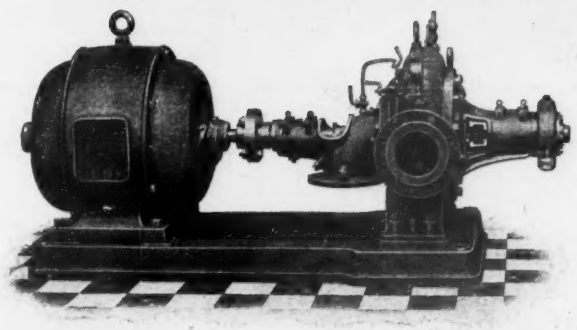


No. E. 122—Portable Iron Smiths' Hearths. No Brickwork Required.

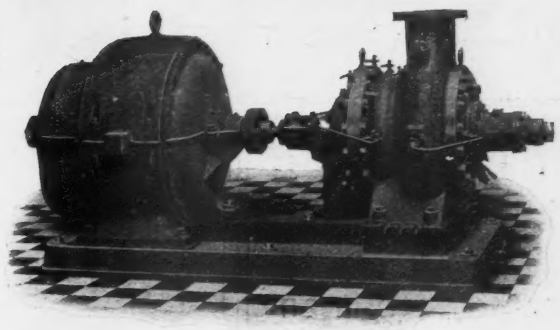
THE "CONQUEROR"

PATENT

TURBINE PUMP.



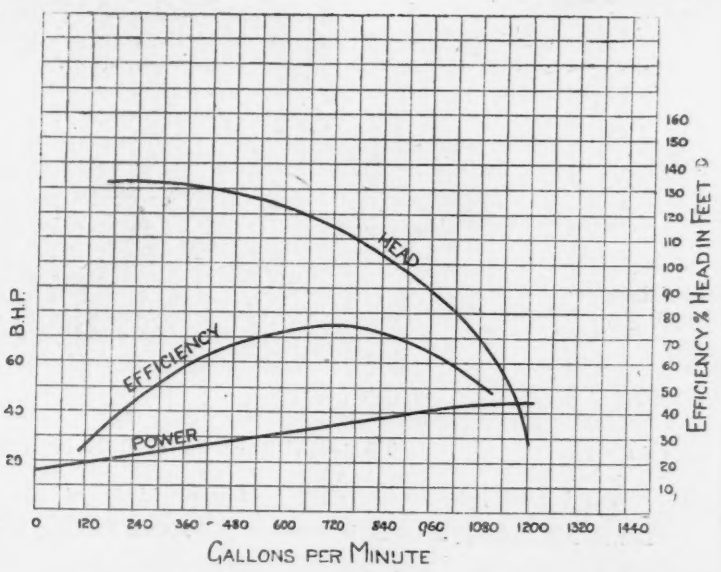
The "Conqueror" High Lift Turbine Pump and Alternating Current Motor. 800 gallons per minute, 250 feet head.



The "Conqueror" High Lift Turbine Pump and Continuous Current Motor. 800 gallons per minute, 500 feet head.

HIGH EFFICIENCY.

HIGH OR LOW LIFT.



STEAM OR MOTOR DRIVEN.

THE "CONQUEROR" TURBINE PUMP

Can be built for either CONSTANT HORSE POWER, VARYING HEAD and QUANTITY or HIGH EFFICIENCY.

W. H. ALLEN, SON & CO.

LIMITED.

QUEEN'S ENGINEERING WORKS, BEDFORD,

AND

Queen Anne's Chambers, WESTMINSTER, S.W.

(Spl) T.R.T. 2

E

ROBEY & CO., LTD.,

Telegrams: "ROBEY, LINCOLN." "ROBEY LONDON."

LINCOLN.

LONDON OFFICE: 79, QUEEN VICTORIA ST., E.C.

WINDING & HAULING ENGINES.

FIXED ENGINES to 3000 h.p.

WITH DROP-VALVES, CORLISS, or SLIDE VALVES.

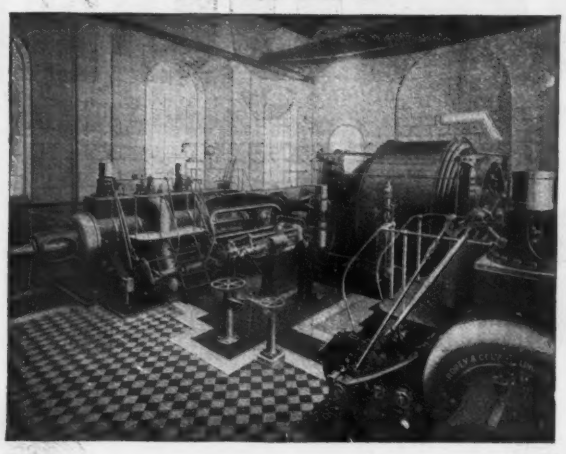
AIR COMPRESSORS.

Any Size.

MINING MACHINERY.

All Kinds.

BOILERS, ALL TYPES.



HIGH-SPEED FORCED LUBRICATION ENGINES.

PORTABLE & TRACTION ENGINES.

SEMI-FIXED ENGINES.

PATENT STEAM WAGONS.

Contractors to War Office, Admiralty, India Office, and all the Principal Foreign Governments. (Spl.) 1007

Wm. MUIR & Co.

LIMITED,

Sherbourne Street, MANCHESTER.

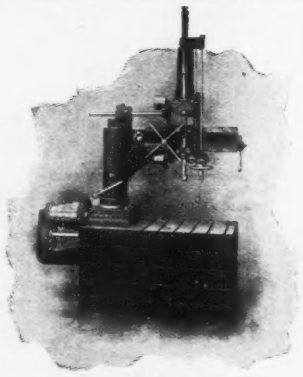
Telegraphic Address—"Britannia, Manchester." Telephone—No. 529.

Specialists in

MILLING MACHINERY

FOR

ORDNANCE, TURBINE, MOTOR CAR & GENERAL ENGINEERING WORK.



IN STOCK OR PROGRESS SLOTTING, DRILLING, BORING MACHINES. J14

STONE BREAKING MACHINES

MASON BROS.,

Brandon Street, LEICESTER, ENGLAND.

Makers of all types of STONEBREAKERS. Thousands now in use. Can be seen working in nearly every town and country in the world. Also makers of a Special Concrete Crusher for Builders, Mortar Mills, Disintegrators, Concrete Mixers, and Grinding Machinery. W5b

LAUNDRY ENGINEERS.

Plans & Estimates Free. Expert Advice given.

Please write for our X1055

NEW CATALOGUE Q.

W. SUMMERSCALES & SONS, Ltd.

Keighley, England.

PILKINGTON BROS., LD.

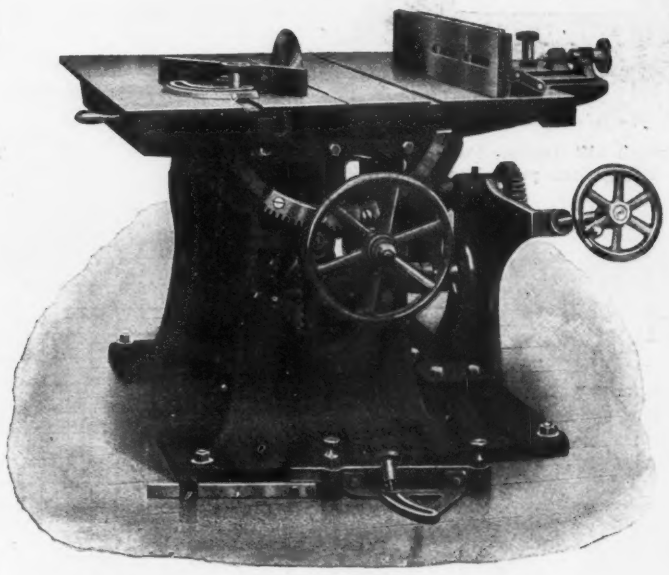
ST. HELENS, LANCS.

Manufacturers of all kinds Plate and Sheet Glass Figured, Rolled, &c. Q585

PATENT WIRED ROLLED GLASS.

PATENT PRISMATIC ROLLED GLASS

See Large Advertisement every Fourth Week.



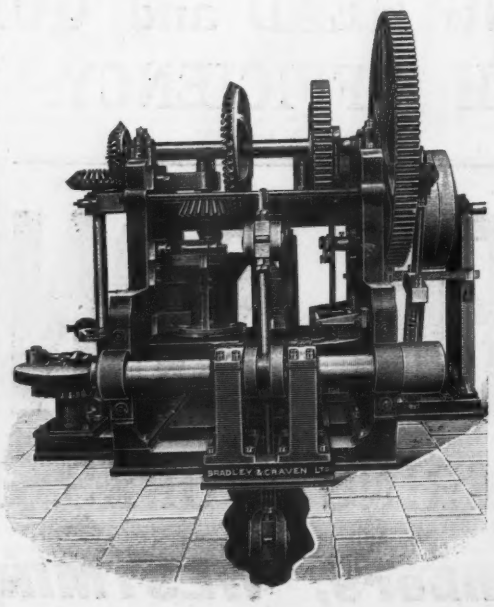
TWO-SPINDLE SAW BENCH—Type AB.

For all kinds of

Dimension Sawing, such as is required in Pattern Making, Cabinet Making, Fine Joinery, &c.

THOS. ROBINSON & SON, Ltd., ROCHDALE

F1635 *LONDON: 79, QUEEN VICTORIA STREET, E.C.* (13)



BRIQUETTING IRON AND OTHER ORES, COAL, &c.

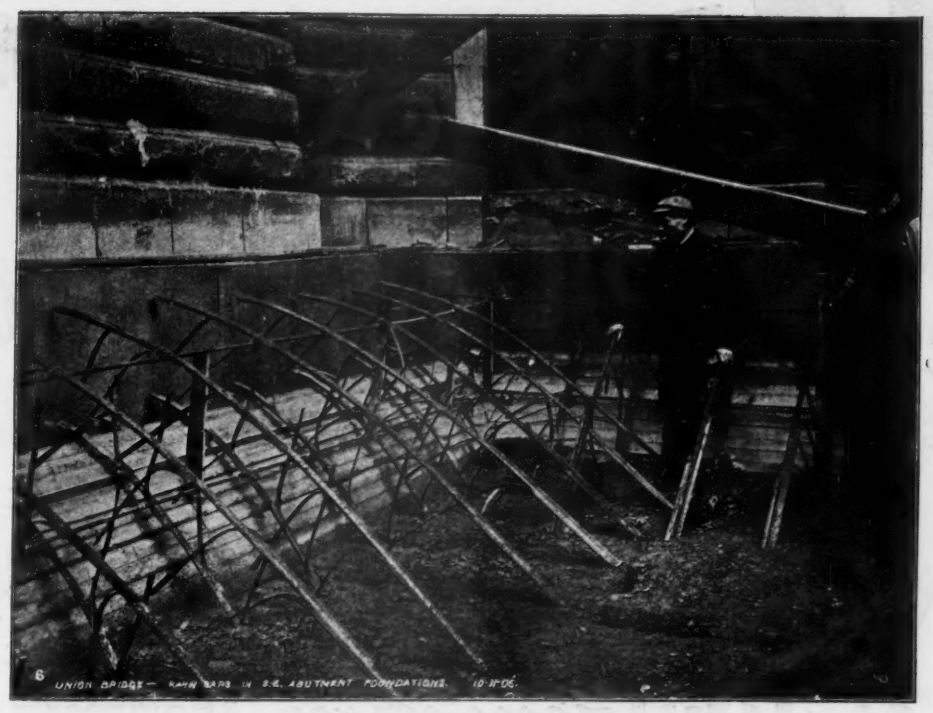
The Machine here represented is the strongest and most efficient on the market. All levers, cranks, dies, and principal parts MADE OF STEEL. Exerts an enormous pressure on each side of briquette, and requires little power to drive.

Sole Makers— X1580

BRADLEY & CRAVEN, LIMITED,

Engineers, WAKEFIELD.

REINFORCED CONCRETE.



THE KAHN SYSTEM claims to be the MOST PRACTICABLE, as well as the MOST SCIENTIFIC, method for the Reinforcement of Concrete.

HOW CAN THIS CLAIM BE SUBSTANTIATED?

(1) **Look** at the BAR.

Note the shear members—they are actually **a part of the main bar,** and bent to an angle of 45 degrees. Rigid position of bar within the concrete is thus secured, besides a complete reinforcement of the **upper** as well as the **lower** portion of the concrete. The main bar is diamond-shaped, thus combining strength and efficiency with lightness and economy of reinforcement.

(2) **Study** the TESTS.

THE KAHN SYSTEM has been subjected to exhaustive tests, which have established beyond all doubt the facts that it is FIREPROOF, EFFICIENT in STRENGTH and DURABILITY, ECONOMICAL, and that it satisfies every demand of practical and scientific construction.

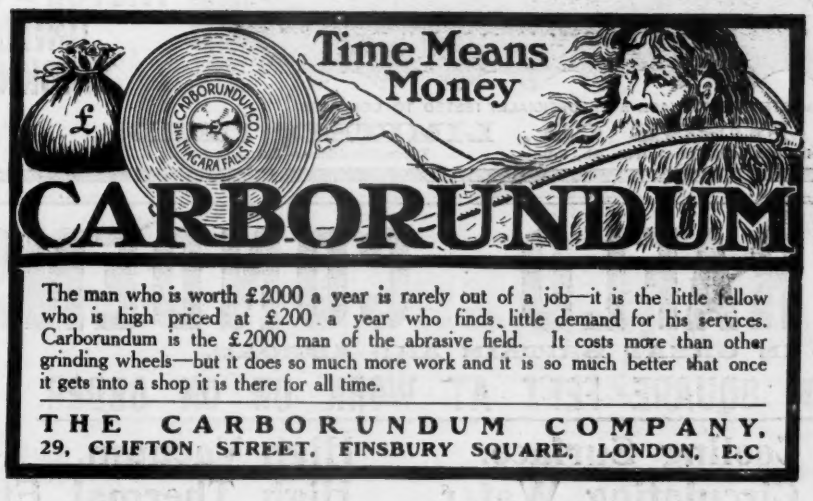
(3) **Think** of £10,000,000 worth of STRUCTURES

which have been erected on the KAHN SYSTEM. This System is designed as a Reinforcement for floors, walls, beams, columns, and, in fact, every constructional detail in any class of structure, including BRIDGES, RESERVOIRS, AQUEDUCTS, GAS-TANKS, RETORT FOUNDATIONS, PUBLIC BUILDINGS, FACTORIES, HOTELS, HOSPITALS, STAIRCASES, ROOFS, &c. &c.

(4) **Ask** for our HANDBOOK.

It tells briefly and intelligently more about the BAR, the TESTS, and the £10,000,000 worth of STRUCTURES. It will be sent FREE to all ENGINEERS who will apply for it on their professional stationery. A postcard will do.

THE TRUSSED CONCRETE STEEL CO., LTD.,
54, CAXTON HOUSE, WESTMINSTER, S.W. Z386



The man who is worth £2000 a year is rarely out of a job—it is the little fellow who is high priced at £200 a year who finds little demand for his services. Carborundum is the £2000 man of the abrasive field. It costs more than other grinding wheels—but it does so much more work and it is so much better that once it gets into a shop it is there for all time.

THE CARBORUNDUM COMPANY,
29, CLIFTON STREET, FINSBURY SQUARE, LONDON, E.C

"DODGE" PULLEYS MADE IN CANADA.

Absolute Satisfaction Guaranteed.

More Adhesive Belt Surface than either Steel or Iron.

Lightest and Cheapest on the Market.

Sole Importers:

GANDY'S LTD., Q518
SEACOMBE, LIVERPOOL.

DAVIE & HORNE
JOHNSTONE, N.B.

Tel. Address—Evaporator, Johnstone.

Sole Manufacturers of the "Davie" Patented Specialities in Feed Water Filters, Conjoined Filters and Heaters, Evaporators, F.W. Distillers, Winch Condensers, Boiler Feed and Ballast Pumps, &c. &c. Q478

London Office—155, Fenchurch St., E.C.

WOOTTON BROS., LD.,
COALVILLE, near LEICESTER.
Telegrams—Wootton, Coalville E1709
Brickworks Plant. Sanitary Pipe Plant
CLAY-WORKING PLANT.
Colliery Plant. General Millwright.

SHAFTING
AND FITTINGS.
C. F. CARVER, LTD
Alfred Street Mills, Q501
NOTTINGHAM.

SPRINGS
Spring Washers, Files & Steel.
The Tempered Spring Co. Ltd. Q439
SHEFFIELD.

READER HIGH SPEED ENGINES.
E. READER & SONS, Ld.,
NOTTINGHAM, and
5, New London Street, E.C.
Q445

The PATENT "ACME" (Regd.)
STONEBREAKER
FINE CRUSHING ROLLS,
Sole Makers—GOODWIN, BARSBY & CO.
Engineers & Ironfounders, LEICESTER.

KEY-WAY & OIL GROOVE CUTTING MACHINES.
THE NEVILLE MACHINE TOOL CO.,
7, James St., LIVERPOOL. LTD.

Draw-Stroke Trimmers for Wood.
Q542
CROSIER, STEPHENS & Co.
NEWCASTLE-ON-TYNE.

INDIA RUBBER

"Simplex" Cotton Belting. Canvas Fire Hose.

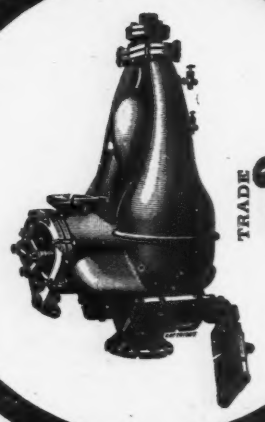
DURIFLEX Patent

Celluvert FIBRE

THE BEST
Asbestos and Metallic
HIGH PRESSURE
PACKING

DAVID MOSELEY & SONS, Ld.,
CHAPELFIELD WORKS. ARDWICK, MANCHESTER.

(Spl) BM36



The Best Pump
TRADE The Pulsometer MARK.
STEAM PUMP
for General Use.
Ask for List No. 10.

Telegrams—
Pulsometer, Reading.
Pulsometer, London.

Pulsometer Engineering Co., Ltd.,
LONDON:
Offices & Showrooms,
61 & 63, Queen Victoria St., E.C.
READING:
Works,
Nine Elms Ironworks.

The UNITED ASBESTOS Co., Ltd.

ASBESTOS GOODS, BOILER COVERINGS, OILS AND GREASES, AND ENGINEERS' STORES.

Spl. BM26

SUSPENSION BULB FURNACE.
(PATENT).

BOARD OF TRADE,
CONSTANT for
SUSPENSION
BULB FURNACE,
15,000.

THE STRONGEST FURNACE MANUFACTURED.

BOARD OF TRADE,
HIGHEST CONSTANT
for OTHER
CORRUGATED TYPES,
14,000.

HIGHEST FACTOR of SAFETY. UNIFORM THICKNESS.

GREATEST DIAMETER OF FURNACE EVER OFFICIALLY TESTED TO COLLAPSE

THE LEEDS FORGE CO., LIMITED, LEEDS.
London Office—Mr. Joseph Hallett, 108, Fenchurch St., E.C. Telegraphic Address—Engisous, London.

(Spl) BM38

THE CONTRAFLO CONDENSER

PATENTED IN GREAT BRITAIN AND ABROAD.

280,000 SQUARE FEET AT WORK OR ON ORDER.

ADVANTAGES.
Minimum Cooling Surface. High Vacuum.
Minimum Circulating Water. High Thermal Efficiency.

For full particulars and License to manufacture apply to:—
THE CONTRAFLO CONDENSER CO., Ltd., 3 & 5, Crown Court, Old Broad Street, LONDON, E.C.
Telephone—2369 LONDON WALL. Telegrams—CONTRAFLO, LONDON. (Spl) BM

Printing.—Geo. Reveirs. many years Manager for and Successor to the PRINTER of "THE ENGINEER" from its COMMENCEMENT, will promptly furnish Estimates for any description of Printing.—5 and 5, Graystoke-place, Fetter-lane, E.C. N6

Jensen and Son,
CHARTERED PATENT AGENTS
(Established 1858), obtain British, Colonial, and Foreign Patents, and Trade Marks and Designs Registrations.—Full information on application, 77, Chancery-lane, London, W.C.

James D. Roots and Co.,
Thanet House, Temple Bar, London, W.C. British and Foreign Patents, Trade Marks and Designs.
Expert evidence in the Courts in Engineering or Patent cases. Compilers of the Patent Abstracts for "THE ENGINEER," for the *Times* (Engineering Supplement), and for the *Automotor*.
Provisional Protection, £3 3s. Quotations given for the Complete British Patent and for Foreign Patents. nx405
Advice to Inventors Free. Advice in the Construction of New Inventions. Working Drawings made for Inventors.
Tel.: 12327 Central. T.A.: "Oaktree, London."

Patents.—G. F. Redfern and Co.,
CHARTERED PATENT AGENTS, 4, South-street, Finsbury, E.C., and 21, Southampton-buildings, W.C. Established 1830. British, Foreign, and Colonial Patents obtained at Fixed and Moderate Charges. Designs and Trade Marks registered at home and abroad. Circular of information forwarded free on application. Telephone No. 4492 Central. Teleg. Address, "Invention, London." O1502

Patents. — Harris and Mills,
PATENT AGENTS, 23, Southampton-buildings, London, W.C. (Established 1866), UNDERTAKE ALL BUSINESS connected with Patents in the United Kingdom, the Colonies, and all foreign countries. Booklet of useful information gratis. Attendance in the Provinces at moderate charges. A Chart of 187 Mechanical Motions, with description of each, post free, 6d. K1

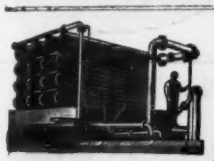
Patents.—Messrs Vaughan & Son
(Established 1853), British, Foreign, and Colonial PATENT AGENTS, transact every description of business connected with Letters Patent for Invention. "A Guide to Inventors," free by post.—57, Chancery-lane, London, W.C. K2

Stephen Watkins, Son & Groves,
CHARTERED PATENT AGENTS,
75, CHANCERY-LANE, LONDON, W.C. (T.N.: 2136 Holborn). and at Prince's-square, Wolverhampton. Established 1869. (Spl) AM146

THOMAS SHANKS & CO.,
Johnstone, nr. Glasgow. Sole Makers of
SCREWING & TURNING MACHINES,
BARROW'S RECENT PATENTS and other great Improvements to date.
Eight sizes, 1¼in., 2in., 2½in., 3in., 3½in., 4½in., 5½in. & 6½in.
BOLT SCREWERS ONLY, 1in., 1¼in., 2½in. and 3½in.
For other Machines see Illustrated Advertisement, Third Issue in each Month. (Spl) AM119

BULL'S METAL & MELLOID CO.,
HEAD OFFICE AND WORKS: LIMITED,
YOKER, nr. GLASGOW.
Teleg., MELLOID, YOKER. Nat. Tel. No. 0182 CLYDEBANK.
BULL'S METAL.—Propellers, Bars, Sheets, Pump Rods, Valve Spindles, Condenser Stays and Plates, &c.
MELLOID (Reg. Trade Mark and Patented).—Condenser Tubes, Plates, and Stays, Boiler Tubes, Stays, and Plates, Fire-box Plates, Bars, Sheets, Valves, &c.
WHITE METALS.—Babbitt's, Plastic, &c. (Spl) AM120

LEDWARD'S PATENTED SPECIALITIES



Evaporative Condenser.

EVAPORATIVE & EJECTOR CONDENSERS.

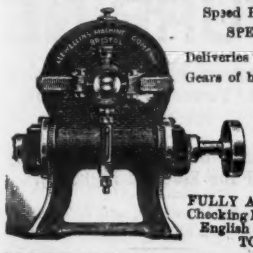
All Types OF CONDENSERS, AIR PUMPS, &c. To Order.

STEADY VACUUM 24in. to 27in.
30 to 60 per cent. of *FUEL SAVED*

For full particulars, Catalogues, Prices, &c., apply to
LEDWARD & BECKETT,
Sanctuary House, Tothill St., Westminster, S.W. LTD. AM106

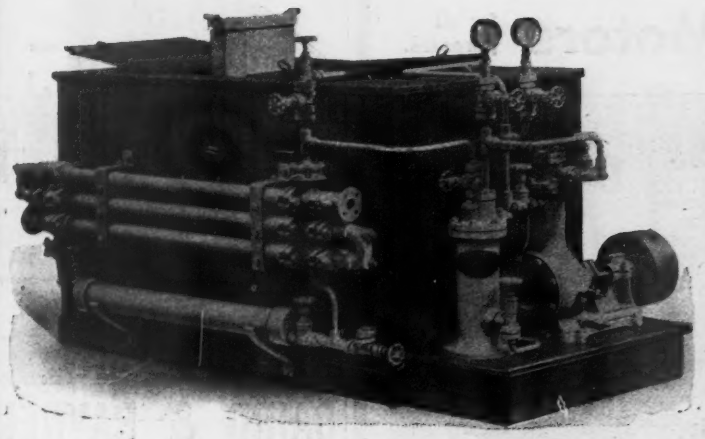
CRAVEN BROS., LTD.,
MANCHESTER & REDDISH.
High-class
MACHINE TOOLS
AND
ELECTRIC CRANES.
AM166
For our Half-page Illustrated Advertisement see last week's and next week's issues.

CUT and CAST GEARING
ALL VARIETIES. ALL SIZES.



Speed Reducing Gears SPECIALISED.
Deliveries to time.
Gears of best selected RAW HIDE.
'REALM' TIME RECORDERS.
The ONLY FULLY AUTOMATIC Time Checking Machines yet made English work, and UP-TO-DATE. AM114
LLEWELLIN MACHINE CO., BRISTOL.

REFRIGERATING AND ICE-MAKING MACHINERY.



SMALL MACHINE WITH ICE TANK.

SIMPLE. EFFICIENT. ECONOMICAL.

L. STERNE & CO., LD.,

The Crown Iron Works, **GLASGOW.**

LONDON OFFICE: DONINGTON HOUSE, NORFOLK STREET, W.C.

(Spl) AM176

HIGH-PRESSURE GAS.
LIGHTING AT HALF USUAL COST
COMPRESSOR for 500 to 4000 c.p. Installation.

FOR
FACTORIES,
SHOPS,
HALLS,
RAILWAY
STATIONS.

All Plants Guaranteed.

Height 44in. Width 13in.

Existing Gas Pipes used.

Efficiency—36 candles per cubic foot of gas consumed.

Automatic and "Fool Proof."

Can be installed by any Plumber or Gasfitter.

Where compressed air is laid on, cost of plant is reduced by 25 per cent.

For full details and photographs of shops using the system, write:—
THE UNITED KINGDOM LIGHTING TRUST, LTD.,
Dept. B., 231, Strand, LONDON, W.C. (Spl) AM 177

EXTRUDED BARS
Of any Plain or Special Section, in Brass, Yellow Metal, Manganese Bronze, Delta Alloys, &c.
Castings, Forgings, Stampings, Sheet, Wire, Tubes, &c., in Delta Metal and other Alloys.
THE DELTA METAL CO., LTD., East Greenwich, LONDON, S.E.
Works—LONDON & BIRMINGHAM. (Spl) AM66

GEORGE RUSSELL & CO.,
Motherwell, N.B. LTD.
ENGINEERS AND BUILDERS OF (Spl) AM134
ELECTRIC, STEAM, HYDRAULIC & HAND
CRANES

BOYLE'S
Latest Patent
"AIR-PUMP" VENTILATOR
Has double the extracting power of earlier forms, and is one-half the price.
Highest Award for Ventilators, Paris Exhibition, 1900. 2 Gold Medals and 1 Silver Medal.
ROBERT BOYLE & SON, Ventilating Engineers.
64, Holborn Viaduct, London, E.C., and 110, Bothwell Street, Glasgow. (Spl) AM132
Catalogues and Price Lists post free on application.

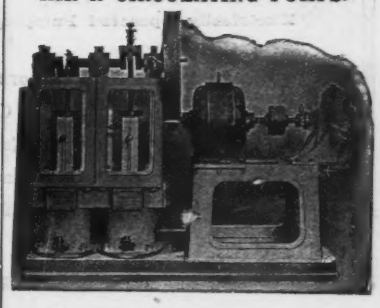
JOHN SWAIN & SON LD

(Spl) AM122

ROYLES LIMITED
Engineers and Specialists,
Irlam, nr. Manchester.
COMBINED REDUCING & SAFETY VALVES.
Perfect Working Guaranteed.
Water Softening and Filtering.

J. & E. HALL, LTD.,
Original Makers in the United Kingdom of
CO_2 REFRIGERATING MACHINES.
AM165
25, St. Swithin's Lane, London, E.C., & Dartford Ironworks, Kent

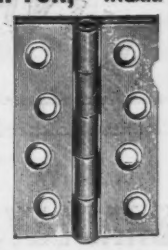
CONDENSING MACHINERY.
AIR & CIRCULATING PUMPS.



ISAAC STOREY & SONS, Ltd.,
Empress Foundry, MANCHESTER.
London Office—46, King William St., E.C. Spl AM 107

"GRAPHITUM"
A Genuine PREPARED PAINT for the effectual protection of all metal surfaces.
MORRIS & WEST, Paint Manufacturers, Chester & Birkenhead. AM171
Write for our Technical Booklet, post free.
London Agents.—John Line and Sons, Limited, Colour Dept., Alfred Place, Tottenham Court-rd., W.C.

THOMAS CROMPTON, Garswood, WIGAN.
Manufacturer of
BEST FORGED WELDED WROUGHT IRON HINGES,
To any pattern for all purposes.
The only British Maker of
BEST STRONG BRIGHT STEEL BUTTS
Double Jointed and Double Flaps.
Also Stock Locks. The best and cheapest Hinges and Locks made. AM174



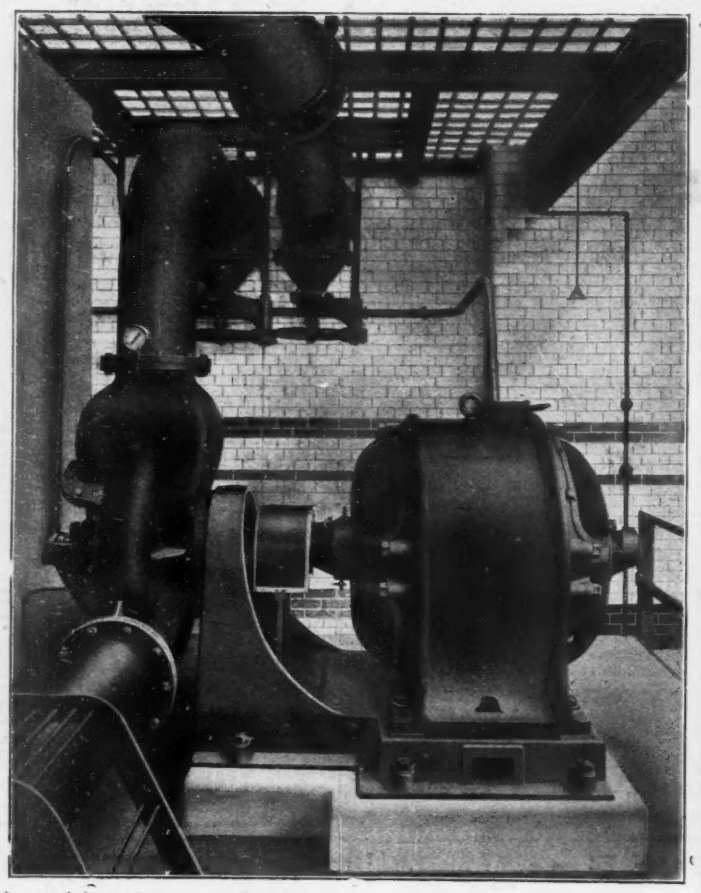
Telegrams—Crompton, North-Ashton.

HULSE & CO., LD
Ordsall Works, MANCHESTER.
HIGH-CLASS
MACHINE TOOLS
SPECIAL & STANDARD. Spl AM123
See Illustrated Advertisement First Issue in each Month

Dick, Kerr & Co. Ld.

London, Preston & Kilmarnock.

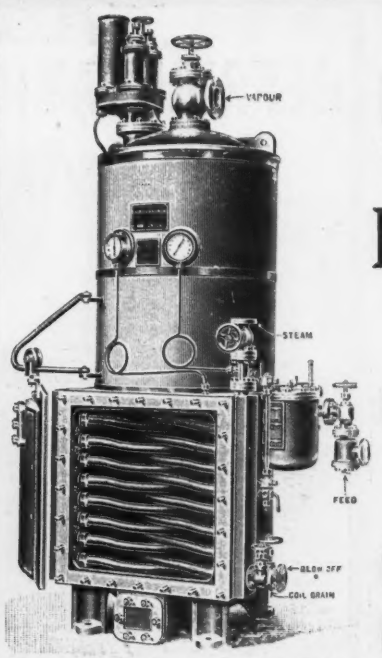
Stationary Motors for all purposes.



Electrically Operated Pumping Plant, Glasgow Corporation.

We have supplied Motors with a total capacity of 641 H.P. to the above Corporation. Some idea of the variety of industrial concerns in which our Motors are operating can be gathered from our Industrial Motor Pamphlet, a copy of which will be sent on application.

Y409



CAIRD & RAYNER'S PATENT

EVAPORATOR.

IMPROVED SINGLE-CYLINDER DIRECT-ACTING

Boiler Feed Pumps

COMPLETE

Fresh Water DISTILLING INSTALLATIONS.

(ALL SIZES)

For LAND or MARINE USE.

FEED WATER HEATERS

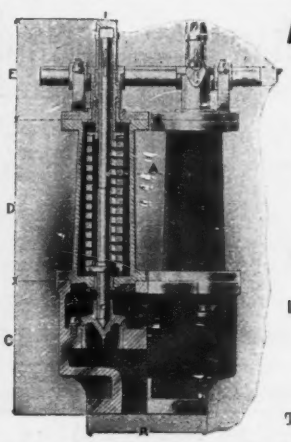
FEED WATER FILTERS

ADMIRALTY CONTRACTORS.

Tel.—Vaporize, London Tel. No. 210 Eastern

CAIRD & RAYNER, Engineers, LIMEHOUSE, LONDON, E. F1302

WALLS VALVE MFG. COMPANY



ARDROSSAN, near GLASGOW.

MARINE SAFETY VALVES

DEADWEIGHT SAFETY VALVES

RELIEF VALVES

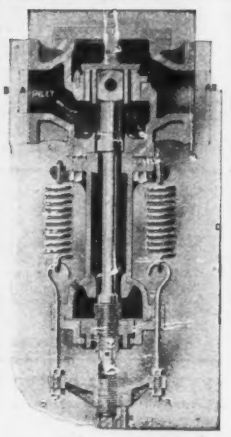
REDUCING VALVES

STOP VALVES Light & Heavy Patterns

FULLWAY WEDGE-GATE VALVES

8M12

Tel. Add., Walls, Ardrossan



TWELVE FIRST AWARDS.

Gold Medal at St. Louis, 1904,

Gold Medal at Edinburgh, 1890, &

Highest Award, Chicago, 1893.

The

PERTH GAUGE GLASSES.

Specially prepared to withstand very High Pressure and great Variation of Temperature. Q860

Manufactured by JOHN MONCRIEFF, Ltd., Perth, Scotland.

Geo. ROBSON & Co.

ECLIPSE WORKS, NAPIER STREET.

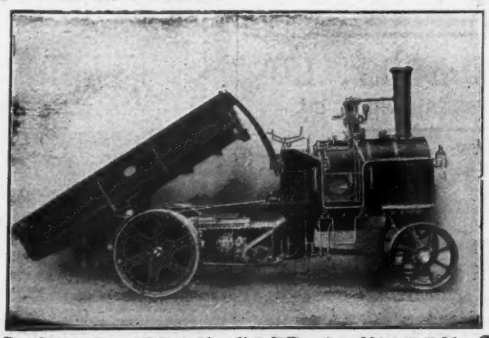
Telegrams—Elevator, Sheffield.
Nat. Tele.—1480

ELEVATORS * CONVEYORS, SCREENS, ETC.

SHEFFIELD

Z257

TO CARRY 2. 3. 5. 7 TONS. 500 SOLD.



MANN'S PATENT STEAM CART & WAGON CO., LD., HUNSLET, LEEDS. Q509

LONDON OFFICE - - - 9, FENCHURCH AVENUE, E.C.

T. & W. BRADLEY, LTD., NEWARK ON TRENT.

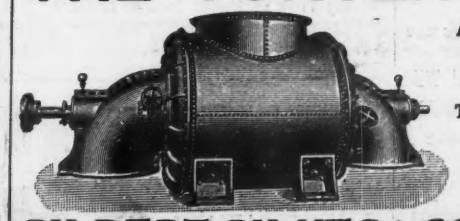
HIGH CLASS, LIGHT & HEAVY

CASTINGS

MECHANICAL, CHEMICAL, and MICROSCOPICAL TESTS.

On Admiralty List. *Est. 1814.* Z183

THE VORTEX TURBINE



An Efficient Means of Applying Water Power to all kinds of Machinery.

This Class of Turbine is largely used for Electric Lighting.

Pamphlets, Drawings, and Estimates on application. M1518

GILBERT GILKES & CO., Ld., KENDAL

TAYLOR & HUBBARD,

Crane Builders,

LEICESTER.

CRANES FOR ALL PURPOSES.

STEAM AND ELECTRIC.

High-class Work and Prompt Delivery.

Q66

Telegrams "LIFTING," LEICESTER.

Nat. Tel. 575.

MUSGRAVE'S - - "ULSTER" FANS.

HEATING. VENTILATING. DRYING.

ELECTRIC FANS.

BELT FANS.

FORCED AND INDUCED DRAUGHT.

ESTIMATES FREE.

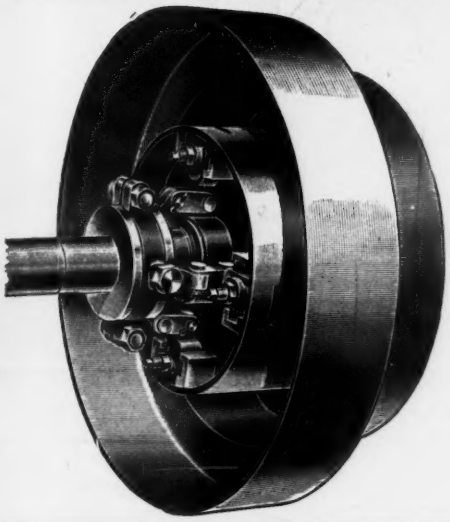
HIGHEST EFFICIENCY & OUTPUT. SUCCESS GUARANTEED

MUSGRAVE & CO., LD.,

53, Victoria Street, London, S.W.; St. Ann's Ironworks, Belfast; 97, New Bond Street, London; 40, Deansgate, Manchester; Guildhall Buildings, Birmingham; 67, Hope Street, Glasgow; and Paris. 358

FRANK WIGGLESWORTH & CO. LTD.

Nelson St. Works, BRADFORD.



FRICTION CLUTCHES.

Machines Driven Direct from Line Shaft.

SEND YOUR INQUIRIES.

Q454

Absolute Satisfaction Guaranteed.

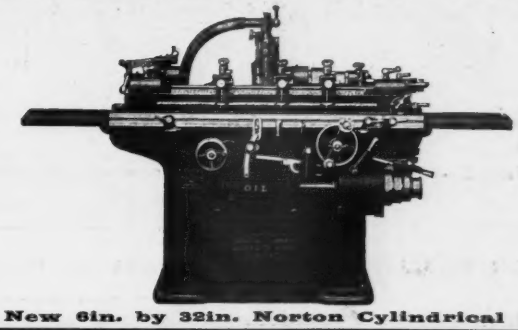
LUDW. LOEWE & CO., LD.

Farringdon Rd. (Opp. 109), LONDON, E.C.

Also 129, Trongate, GLASGOW (P. and W. MACLELLAN, Ltd).

GRINDING MACHINES OF EVERY DESCRIPTION

Telegrams—LOEWE, LONDON. Telephone—1707 HOLBORN.



New E. List free upon application

Z192

The New 6in. by 32in. Norton Cylindrical Grinder.

Koppel's Electric Tramway in a Scotch Mill.

OVER 5000 EXISTING TYPES or NARROW-GAUGE ROLLING STOCK.

WORKS' TRAMWAYS EQUIPPED COMPLETE.

EXPERT ADVICE FREE OF CHARGE.

MANUFACTURERS of STEAM & ELECTRIC LOCOMOTIVES.

Telegrams— ALIGHTING, LONDON.

Telephone— 5724 AVENUE. Z161

ARTHUR KOPPEL, 27 Clements Lane, London, E.C.

THE "D.P." BATTERY FOR RELIABILITY

ITS PLANTÉ-FORMED POSITIVES ALLOW OF HEAVY DISCHARGES WITHOUT BUCKLING

ITS NEGATIVES ARE SPECIALLY DESIGNED TO KEY IN THE ACTIVE MATERIAL AND AVOID SHORT CIRCUITS FROM LOOSE PELLETS

THE "D.P." BATTERY CO., LIM.,

(Established 1888) (On Admiralty and War Office Lists)

BAKEWELL · DERBYSHIRE

MACHINE MOULDED GEAR WHEELS

And Engineers' Castings.

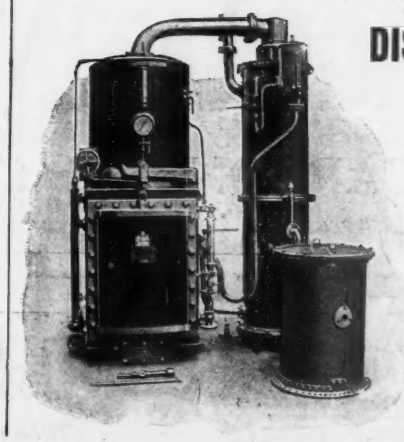
GOOD QUALITY. LOW PRICE. QUICK DELIVERY.

GEORGE JONES, Limited,

LIONEL STREET, BIRMINGHAM. Q402

Telephone 1003. Telegrams—ROLLING.

FRESH WATER FROM SEA WATER.



NORMANDY'S Patent AUTOMATIC

DISTILLING MACHINERY

As supplied to the Admiralty and many Foreign Governments.

With Great Economy of Coal Consumption.

ADVANTAGES CLAIMED.

The apparatus is **SELF-CONTAINED**, and absolutely **SIMPLE** in its working. It produces water of the greatest **PURITY**, which is due to the automatic working. The water is also pleasant to the taste. The specified production is maintained during trials of several days' **CONTINUOUS WORKING** (day and night), and the apparatus has always given satisfaction after **WORKING FOR MANY YEARS.**

NORMANDY'S Patent MARINE AERATED FRESH WATER Co., Ld.

(Opposite Custom House Station),

Normandy St, Victoria Dock Rd., LONDON, E. W1565

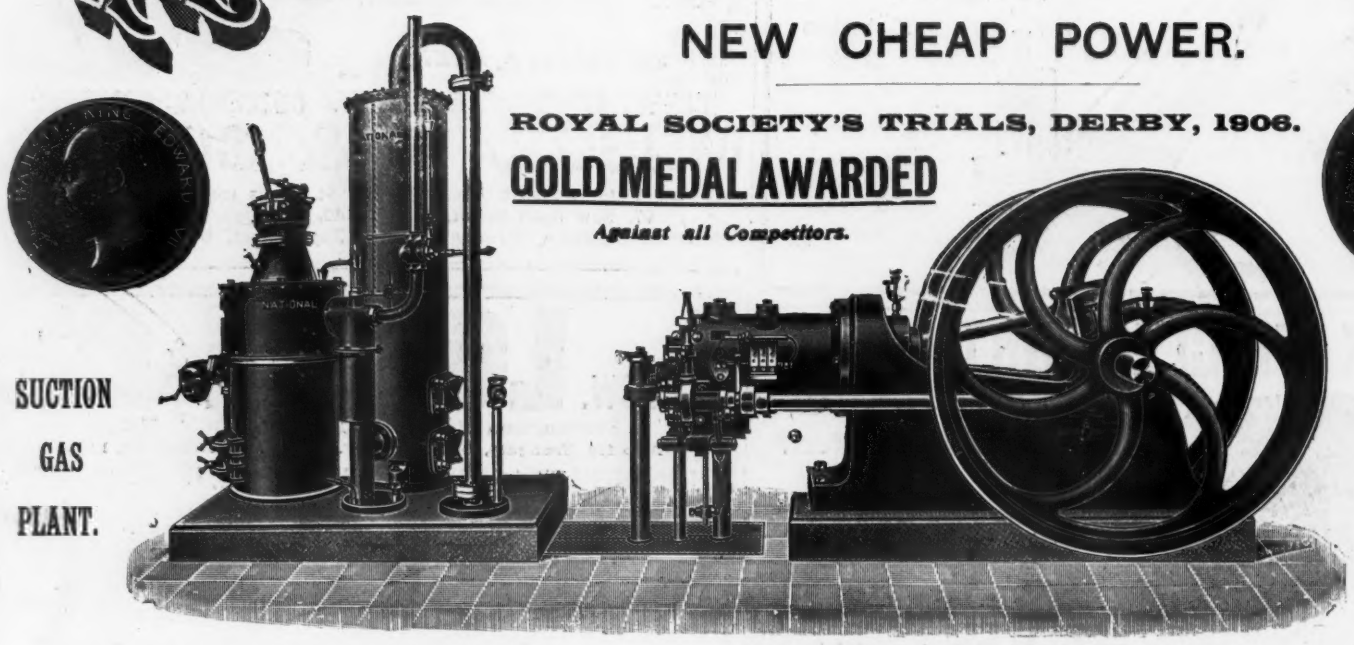
THE NATIONAL GAS ENGINE Co. LTD.

NEW CHEAP POWER.

ROYAL SOCIETY'S TRIALS, DERBY, 1906.

GOLD MEDAL AWARDED

Against all Competitors.



SUCTION GAS PLANT.

The Engine and Plant illustrated above won the* GOLD MEDAL (HIGHEST AWARD) *at the recent trials at the Royal Show, Derby, against all competitors.

WRITE FOR CATALOGUE.

Works and Head Office: **ASHTON-UNDER-LYNE, MANCHESTER.**

LONDON Showroom: 75a, QUEEN VICTORIA STREET.

C6136

PLATES

FOR

BOILERS, SHIPS, BRIDGES

&c.

from ¼in. to 6in. thick.

TO ALL SURVEYS.

CLYDESDALE STEEL.

SIEMENS-MARTIN OPEN-HEARTH STEEL.

BOILER PLATES

SPECIALITY.
Soft Welding and Flanging Plates for Furnaces and other Purposes.

On Admiralty & Board of Trade Lists.

X1804

STEWARTS AND LLOYDS, Ltd., 41, Oswald St., GLASGOW.

Depots
LONDON 108, Southwark Street
MANCHESTER—88, King Street West.
LEEDS—6, Mark Lane, New Briggate.
BIRMINGHAM—114 Colmore Row.

Highest Awards
PARIS, 1855 and 1867.
LONDON, 1862.
MELBOURNE, 1881, and others.

X1805

REFRIGERATING MACHINERY

ON THE

AMMONIA, CARBONIC, & COMPRESSED AIR SYSTEMS.

Adopted by all the Leading Shipowners and Meat Companies in the World.

ICE PLANTS UP TO 200 TONS CAPACITY.

THE HASLAM FOUNDRY & ENGINEERING CO., LD.

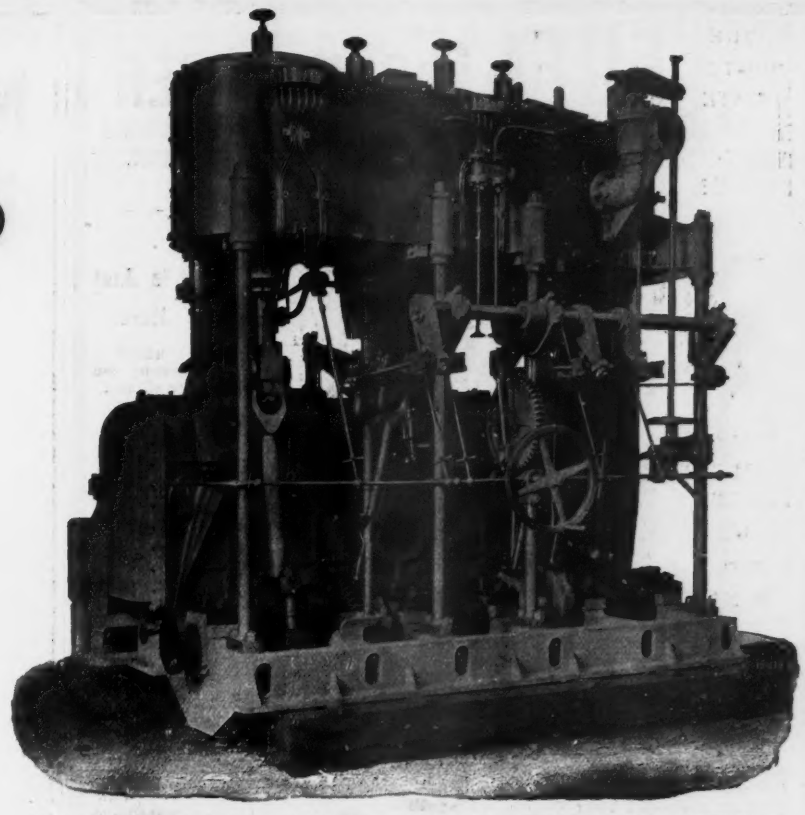
UNION FOUNDRY, DERBY. ***London Office: 175-177, Salisbury House, London Wall, W.C.*** [U1813

MARINE ENGINES

AND

BOILERS of all TYPES.

200 TO 3000 I.H.P.



A. RODGER & CO., ST. HELENS ENGINE WORKS, GOVAN, **GLASGOW.**

NORTH BRITISH LOCOMOTIVE CO., LTD.,

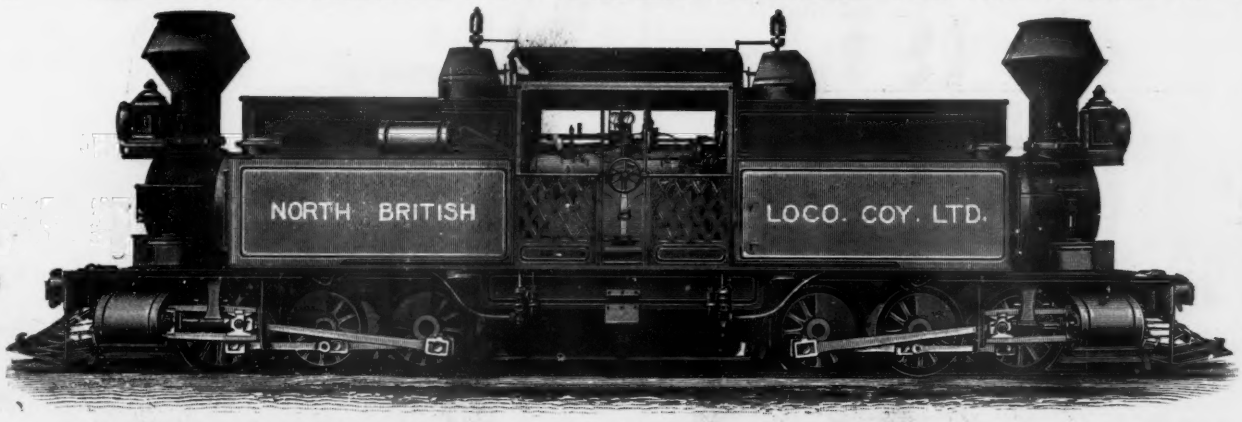
Hyde Park Works. (Late NEILSON REID & CO.)
Queens Park Works. (Late DUBS & CO.)
Atlas Works. (Late SHARP, STEWART & CO., Ltd.)

HEAD OFFICE: HYDE PARK WORKS, SPRINGBURN, GLASGOW.
Telegrams—LOCO, GLASGOW.

London Office: 17, VICTORIA STREET, WESTMINSTER, S.W.
Telegrams—HYPAR, LONDON.

BUILDERS OF ALL KINDS OF **LOCOMOTIVE ENGINES AND TENDERS SUITABLE FOR ANY GAUGE OF RAILWAY.**

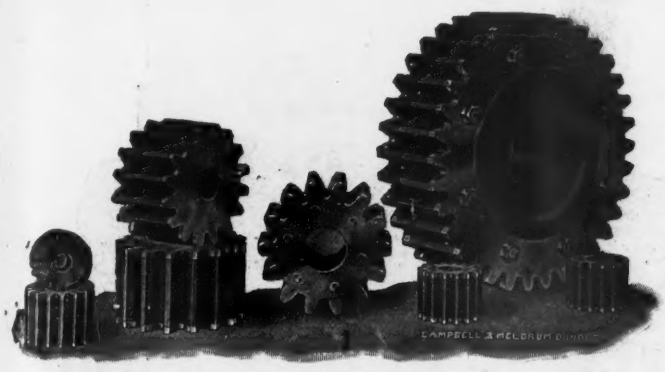
Annual Capacity 700 MAIN LINE LOCOMOTIVES



Workshop Equipment 8000 Men

OUTPUT NOW EXCEEDS 18,000 LOCOMOTIVES

THE LARGEST LOCOMOTIVE WORKS IN EUROPE.



WHEELS

OF ALL DESCRIPTIONS

MACHINE MOULDED & MACHINE CUT.

RAW HIDE & COMPRESSED PAPER PINIONS.

THOUSANDS OF MODELS to Select from.
URGENT BREAKDOWN WHEELS a Speciality.
Quotations and all information freely given.

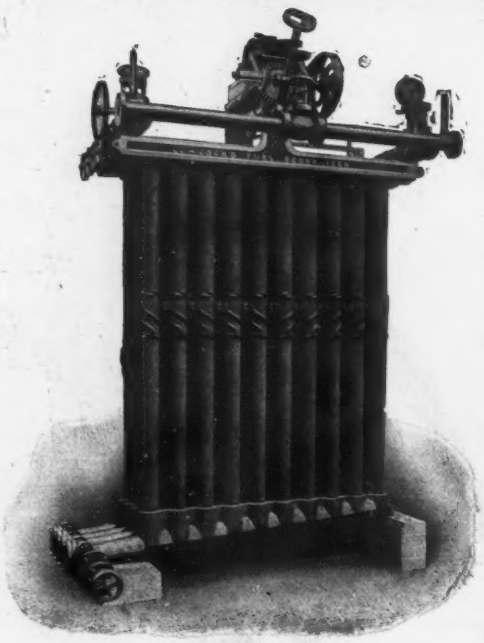
URQUHART, LINDSAY & CO., Ltd., BLACKNESS FOUNDRY, DUNDEE

THE UP-TO-DATE

FUEL ECONOMISER

LOWCOCK'S PATENT.

For HIGHEST PRESSURES.



Coal is now Costly, so Economy is more Urgent.

It is Just Here where economy can be effected by this apparatus.

And the Saving in Coal is 15 to 25%.

It's not only the Saving in Coal, but Steaming Power is increased—there's more work with less effort—and boiler life is prolonged also—all solid advantages for Steam Users. Send us along details of your plant—we'll figure an economy scheme for you. We've had 30 years' experience with this Speciality. Z242

A. LOWCOCK, Ld. Shrewsbury.

THE

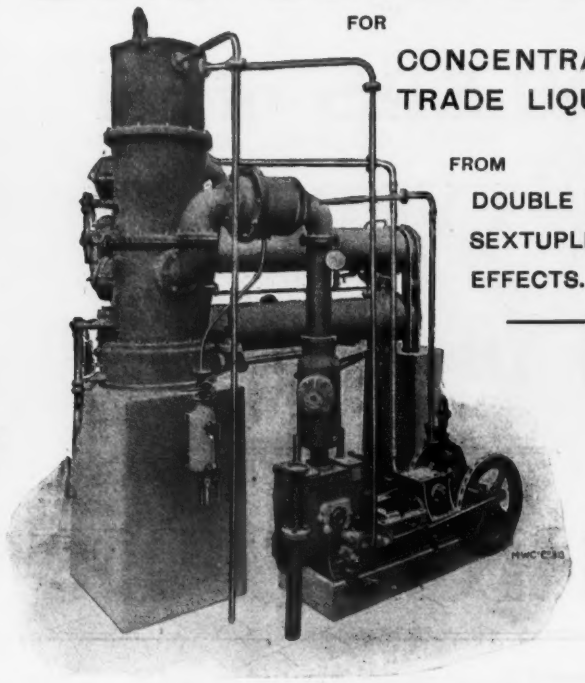
MIRRLEES WATSON CO., LTD.,

GLASGOW.

EVAPORATORS

FOR CONCENTRATING, TRADE LIQUORS, ETC.

FROM DOUBLE TO SEXTUPLE EFFECTS.



"DOUBLE EFFECT" EVAPORATOR.
CAPACITY TO TREAT 140 GALLONS GLUE PER HOUR

Tele. Add.: "MIRRLEES, GLASGOW." Q75

LONDON OFFICE: 139, GRESHAM HOUSE, OLD BROAD ST., E.C.

Telegrams—"LAMINATED, GLASGOW"—"CHEVERAL, LONDON.

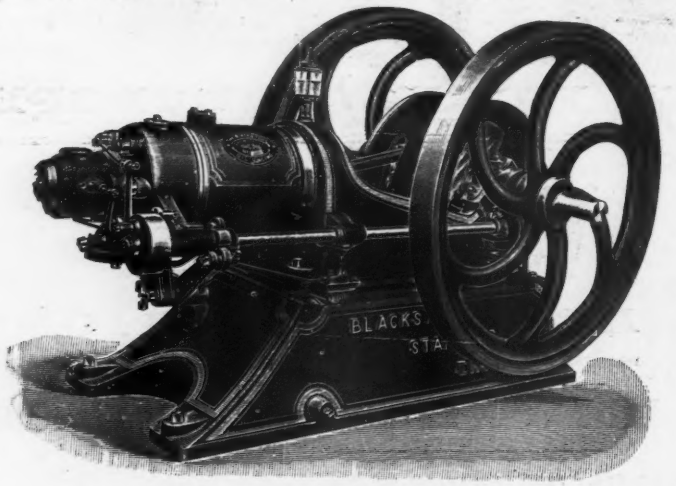
HENDRY'S PATENT LAMINATED LEATHER BELTING

JAMES. HENDRY. BRIDGETON. GLASGOW.

London Address: 7, BISHOPSGATE STREET WITHOUT, E.C
E161

THE BLACKSTONE OIL ENGINE.

Stationary Type, 2 to 70 B.H.P. Portable Type, 2 to 26 B.H.P.



From Photo of 14 B.H.P. ENGINE.

Works with Ordinary Lamp Oil, Petrol or Alcohol. Starts in 4 minutes.
No Lamp required except for starting. No external flame when working.

Telegrams—Blackstone, Stamford. Telephone—No. 1, Nat. Codes used—Lieber's, A1, ABC (4th and 5th Editions

Estimates and full particulars post free. A1966

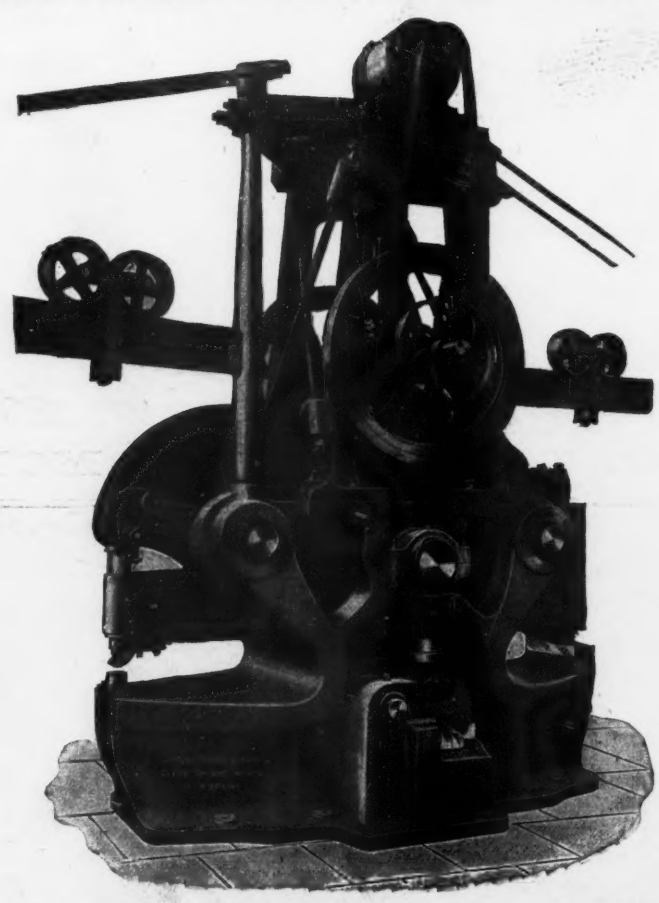
BLACKSTONE & CO., Ld., STAMFORD, ENG.

London Offices and Showrooms—81, CANNON STREET, E.C.

Telephone—No. 8144 Central. Telegrams—Engimanu, London.

Adelaide—61-63, Hindley Street. Alexandria—Rue de la Gare du Caire. Bombay—3, Hummum Street. Cairo Rue Bab-el-Hadeed Calcutta—99, Clive Street. Christchurch, N.Z.—South Belt. Sydney—15, Macquarie Place. Toronto—14-16, King Street East. Moscow—Miasnitsky Proezd House Nemchinoff. Geraldton, W.A.—Marine Terrace. Amsterdam—Spuistraat 6 and 8.

SHIPYARD MACHINE TOOLS.



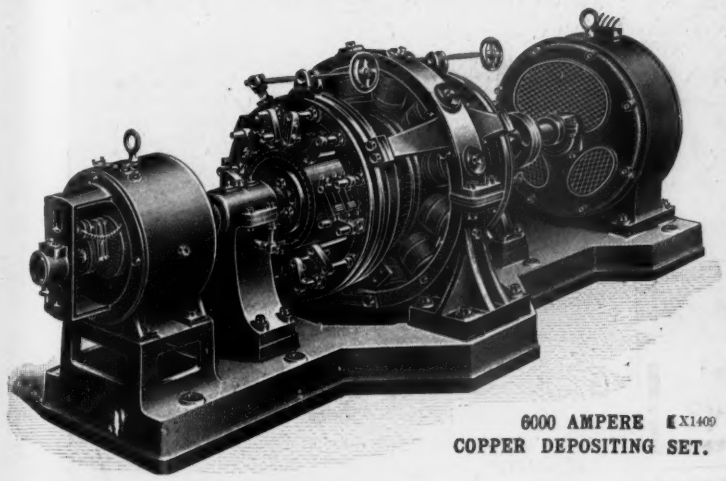
JAMES BENNIE & SONS,

Clyde Engine Works, aa25a

Cardonald, **GLASGOW.**

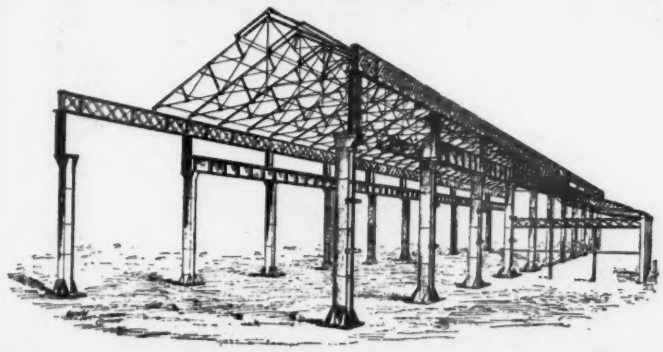
WILSON HARTNELL & CO.
LIMITED,
VOLT WORKS, LEEDS.

ELECTRO-PLATING DYNAMOS
CENTRIFUGAL ACID PUMPS.



6000 AMPERE X1409
COPPER DEPOSITING SET.

STEEL FRAMED BUILDINGS
of Every Description.



BROWNLIE & MURRAY,
POSSIL PARK, GLASGOW. Ltd.
CATALOGUES free on Application. Refer New Edition A (as at)
LONDON: 16, St. Helen's Place, E.C

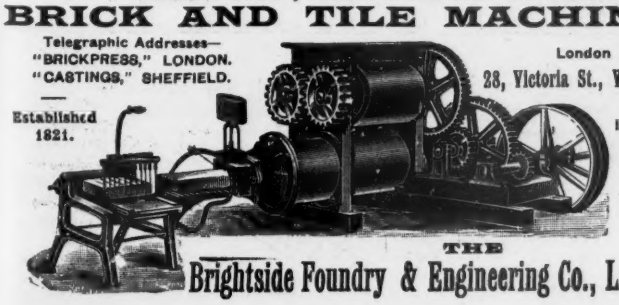
TEXTILE BELTING.

Twenty-five years of practical experience in the actual manufacture of belting, coupled with an intimate knowledge of the various markets, enables us to offer exceptional value to both dealers and shippers whose wants we have made a special study.

BALATA, HAIR & COTTON BELTINGS.

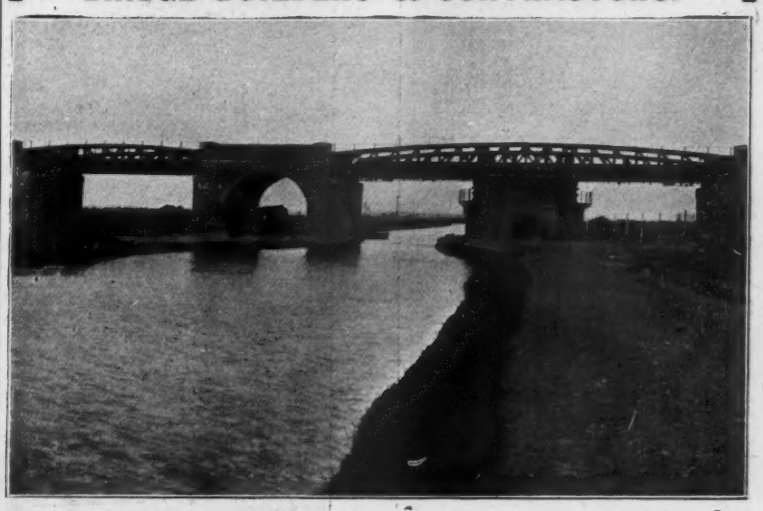
HENRY A. COLE & CO.,
Coronet Works) B Dept.), LIVERPOOL. Z258

CLAYTON, HOWLETT & CO.'S
BRICK AND TILE MACHINERY.
Telegraphic Addresses—
"BRICKPRESS," LONDON.
"CASTINGS," SHEFFIELD.
London Office—
28, Victoria St., Westminster, S.W.
Established 1821.



ILLUSTRATED CATALOGUES ON APPLICATION.
Sole Makers—
THE Q571
Brightside Foundry & Engineering Co., Ld., Sheffield

THE
CLEVELAND BRIDGE & ENGINEERING Co.
DARLINGTON, ENGLAND. LTD.
BRIDGE BUILDERS & CONTRACTORS.



Viaduct, with swing span, at Crowle, for the Lancashire and Yorkshire and North-Eastern Railway Companies' Axholme Joint Railway. Q473

SPECIALISTS IN DEEP FOUNDATION WORK.

THE BAKER OIL SEPARATOR
FOR EXHAUST STEAM
IS THE BEST ON THE MARKET.
Particulars and Illustrated Catalogue Free.
BAKER'S PATENT APPLIANCES CO., LTD.,
Wires— PATENT, SCARBOROUGH. Dept. C SCARBOROUGH. D18
LONDON Representative—VICTOR COATES, M.I.M.E., 2, Norfolk St., STRAND, W.C.
Telephone No.—3261 GERRARD. Telegrams—VICTOMINE.

HODGES' Patent
STEAM TURBINE BLOWERS.

No Gearing. No Belts. No Friction.

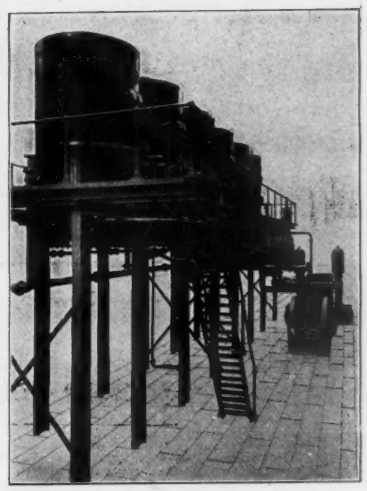
Suitable for
Forge Fires, Foundry Cupolas, Gas Furnaces, Sand Blast Machines, Alkali Works, Water Gas Plants, &c.

MADE ALSO FOR EXHAUSTING.

Prices and particulars on application.

HODGES & CO.
Engineers, Z240
14, Devonshire Square, Bishopsgate, LONDON, E.C.

FAWCETT, PRESTON & CO.
LIMITED,
Telegrams—Fawcett, Liverpool. Codes used.—A B C (4th and 5th Editions), A1, and Western Union
Engineers, LIVERPOOL.
London Office: 69, VICTORIA STREET, S.W.
Contractors to the ADMIRALTY and WAR-OFFICE.



Sextuple Effect Sea Water Distilling Apparatus.

Sugar Making Plant of all kinds.
Distilling & Evaporating Machinery.
Stationary and Marine Engines and Boilers.
Pumping Machinery for Town's Water Supply.
Winding and Hauling Engines and Air Compressors.
Sole Makers of Cyclone Presses. Sole Makers of Grid Presses and of Fawcett's High Density and Compound Hydraulic Presses & Pumps for Packing Cotton, Jute, Wool, Silk, Hides, &c., to any required density and weight of Bale.
U1893

AGENTS FOR LONDON AND SOUTH:—
George Richards (London), Ltd., 31, Finsbury Square, E.C. Z58

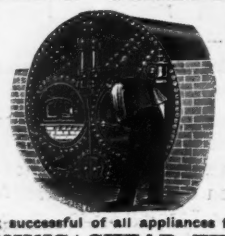
ATLAS
BEST WHITE
ANTI-FRICTION
METAL
Address: 52, Queen Victoria Street, London, E.C.
Z177

QUIGGIN'S PATENT
EVAPORATORS, HEATERS, FILTERS, CONDENSERS,
AND COMPLETE
Distilling Plants for Ship & Shore Use.
The Liverpool Engineering & Condenser Co., Ltd.,
Brunswick Dock, LIVERPOOL Q491
London Office—40, Fenchurch Street, E.C

BRUCE & STILL, LTD.,
49, Sefton Street, LIVERPOOL,
Constructional Engineers and Contractors
Iron and Timber Buildings, Roofs, Bridges, Gladers, and other constructional work.
Contractors to H.M. Government. Q501
See our Illustrated advertisement previous and next

SPIRAL SPRINGS. SPIRAL SPRINGS.
When requiring Spiral or Small Flat Springs for any purpose in connection with your Engines and Machines send your enquiries to
The LION SPRING CO., Oldbury (B'ham),
who are makers to some of the largest Gas Engine and Motor Car Makers, Railway Wagon, Carriage and Tramcar Builders in the World.
See advertisement appearing alternate weeks. Q513

Perforated Metals
Artistic Metal
W. BARNS & SON
Name Plates
CHEMICALLY ENGRAVED NAME PLATES.
PERFORATED STEEL PLATES, CYLINDERS ETC TO ½ INCH THICK.
METALLIC NAME PLATES IN BRASS, IRON, ALUMINIUM, ETC.
W. BARNS & SON CONTRACTORS FOR NAME PLATES TO THE ADMIRALTY
W. BARNS & SON,
Globe Works, Queensland Road, Holloway, N.
Telegraphic Address—PERFORATION, LONDON.

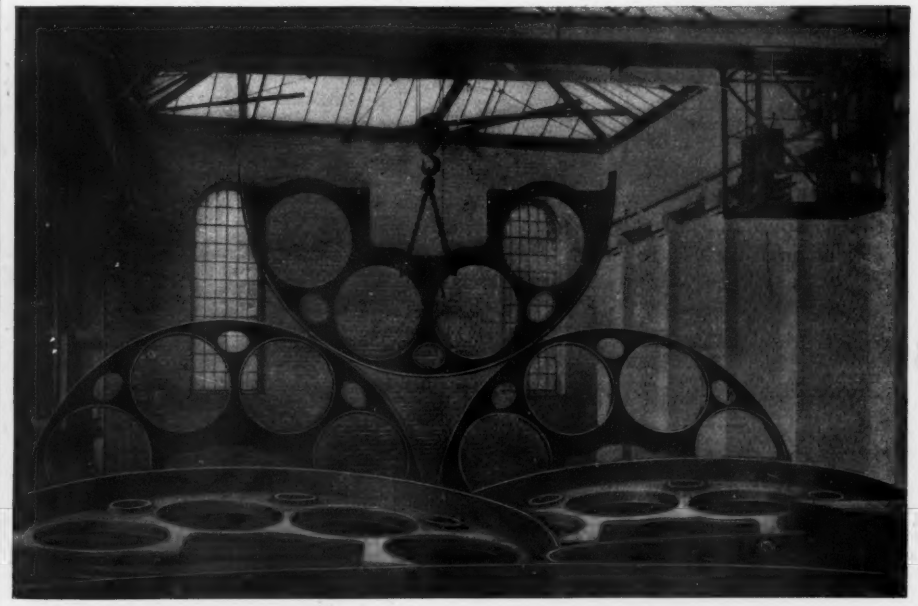
If you want very best Results from your Fuel or from your Boilers, try
NEIL'S (Patent
ROCKING FIREBARS.


Most successful of all appliances for
BURNING CHEAP FUEL
and the most extensively adopted. sm39
JAMES NEIL, 101, St. Vincent St., Glasgow

SIR WILLIAM ARROL & CO., LD.
London Offices: 32, Victoria St., S.W. Dalmarnock Ironworks, BRIDGETON, GLASGOW.
Contractors, Engineers, Bridge Builders & Designers of Structural Ironwork. Also Makers of Hydraulic Pumping Engines. Accumulators

JOINERS' SHOP designed and erected for the Fairfield Shipbuilding and Engineering Co. Roof covered with Glass. Q101
ARROL'S PATENT HYDRAULIC RIVETING MACHINES. CRANES, STAMPING PRESSES &c.

GRICE, GRICE & SON LIMITED
CONTRACTORS TO HIS MAJESTY'S GOVERNMENT
BRASS & COPPER, LOCO & CONDENSER
TUBES
PLATES & RODS &c&c
BIRMINGHAM.

A. F. CRAIG & CO., LTD.,
Engineers, Ironfounders, and Boilermakers,
Caledonia Engine Works, PAISLEY. SCOTLAND.

Telegrams—"CRAIG, PAISLEY.
Codes used—McNeill's Mining and A B C (5th Edition).
ON ADMIRALTY LIST.
Established 1868.
Speciality:
FLANGED BOILER PLATES
Of all descriptions.
To Admiralty, Lloyd's, Board of Trade, Bureau Veritas, and other Surveys.
MARINE, LANCASHIRE, MULTITUBULAR, & CORNISH BOILERS.
Flanging, Riveting, & Bending done by Hydraulic Plant.
Drilling, Welding, & Planing done by special Tools of most modern kind.
sm47

GARDNER OIL, GAS & SPIRIT ENGINES.
L. GARDNER & SONS, Ld., Barton Hall Engine Works, PATRICROFT, MANCHESTER
Telegrams—TANGENT, PATRICROFT. Telephone—No. 40 EARLES. Z381
And 87, Queen Victoria Street, LONDON E.C.

WEBB & SON,
Tanners, Curriers, Fellmongers, Glove and Gaiter Leather Dressers,
LEATHER & WOOL MERCHANTS
MANUFACTURERS OF
LEATHER MACHINE BANDS
FIRE BUCKETS AND HOSE
11 FIRST-CLASS MEDALS AWARDED.
Combs Tannery, Stowmarket
PRICE LISTS AND TERMS ON APPLICATION.

STRUCTURAL STEEL WORK.

STATIONS, WORKSHOPS, GOODS SHEDS, CARRIAGE SHEDS, DOCK SHEDS, &c. &c.

ROOFS

TEA HOUSES, RICE MILLS, SUGAR HOUSES, FACTORIES, LIGHT BRIDGES, &c. &c.

DESIGNS AND ESTIMATES FREE ON APPLICATION.

THE CLYDE STRUCTURAL IRON COMPANY, LTD.,

Q130 Telegrams— CORRUGATED, GLASGOW. Clydeside Ironworks, SCOTSTOUN, GLASGOW.

NEWCASTLE OFFICE—7, Collingwood Street.

London Agents:—Messrs. J. COUPER & CO., 48, Cornhill, E.C.

THOMAS WHITE & SONS, Laigh Park Works, **PAISLEY.**

THE **"White" Compressor**

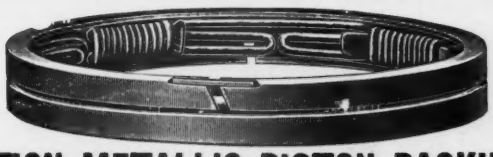
in all Styles, all Sizes, for all Powers, and all Purposes

Tandem Type for Pneumatic Tools, fitted with Automatic A Release and Slowing Mechanism. M23

LOCKWOOD & CARLISLE, Ld.

EAGLE FOUNDRY, SHEFFIELD.

Telegraphic Address— PISTON, SHEFFIELD.



NATIONAL TELEPHONE 1378.

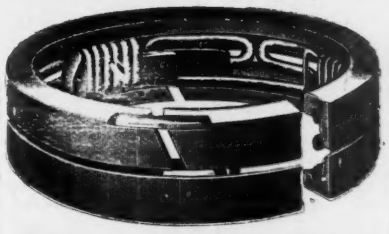
IMPROVED DOUBLE-ACTION METALLIC PISTON PACKING RINGS & SPRING

Carlisle's Patents.

Improved Double-action Piston V Ring.

SPECIAL FACILITIES FOR QUICK DESPATCH OF URGENT ORDERS.

ALL PACKINGS GUARANTEED.



H.P. Rings and Springs, specially designed for High Steam Pressures. T587

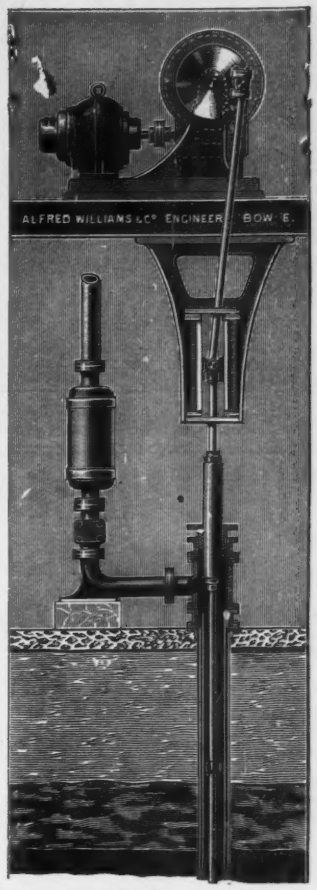
Water Finders

PURE WATER BY ARTESIAN WELLS.

Steam, Electric, Oil, and Wind-Driven Pumps.

AIR LIFTS.

WATER PUMPED BY COMPRESSED AIR



Alfred Williams & Co.,

ARTESIAN WORKS,

BOW, LONDON, E.

Telegrams: VENTULUS, LONDON.
Telephone: 694, EASTERN. Z160

ELECTRICAL REPAIRS

of every description.

Armatures, Stators, and Rotors Re-wound.
Commutators Renewed.

A. HART & CO., Electrical Engineers, Newhaven Road, Bonnington, EDINBURGH.

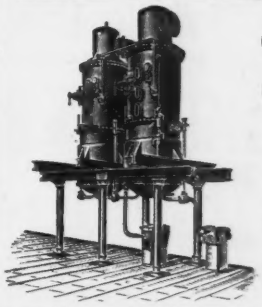
BLAIR, CAMPBELL & McLEAN,

Woodville Street, Govan, LTD.

GLASGOW.

MAKERS OF:—

Sugar-boiling & Refining, Distillery & Brewery Plant.
Multiple Effect Evaporators and Vacuum Pans for all Purposes.
Vacuum Stills. Continuous-working Steam Stills.



Chemical Plant comprising:—

Glycerine Evaporators and Refining Plant
Extractors.
Autoclaves.
Converters.
Saturators.
Condensers.
Refrigerators.
Heating and Cooling Coils.

'Imperial' Drying Machines for Brewers' and Distillers Grains, Dreg, and Sediment.
Manufactured Copper and Brass work of every description.
Brass and Gun-metal Castings. AM44

HARRISON STEERING GEAR.

Cheapest and Best.

TURNBULL'S SAFETY STOP, CHECK SLUICE & REDUCING VALVES.

Send for Valve Sheet.

ALEX. TURNBULL & Co., Ld., Bishopbriggs

Telegrams— Q80
"VALVE," GLASGOW, also "STEERING, GLASGOW.

ROSS & DUNCAN,

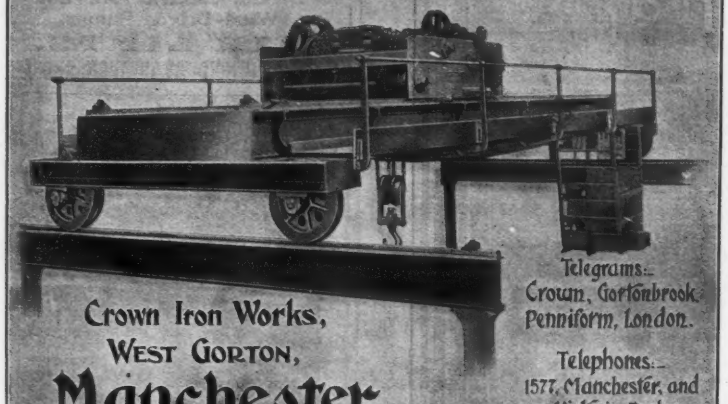
Whitefield Works, Govan, GLASGOW.

MARINE ENGINEERS & BOILERMAKERS

Bremme's Valve Gear. Government Contractors
Duncan's Propeller. Q70

HIGGINBOTTOM & MANNOCK LIMITED.

ELECTRIC CRANES AND HOISTS.



Crown Iron Works,
West Gorton,
Manchester.
London Office—25 Victoria St. Westminster.

Telegrams:—
Crown, Gortonbrook,
Penniform, London.

Telephones:—
1577, Manchester, and
182, Victoria Exchange
London.

THE

Vulcan Boiler & General Insurance

COMPANY, LIMITED. (Established 1859.)

THE ORIGINAL BOILER INSURANCE COMPANY

Head Office - - 67, KING STREET, MANCHESTER.

INSURANCE and INSPECTION

OF

BOILERS, Economisers, Steam Pipes, Kiers, Superheaters, Decouduns and Lifts and Hoists. **ENGINES** (Steam, Gas or Oil), and **GAS PRODUCER** Plant. **ELECTRICAL** Machinery.

EMPLOYS MANY MORE INSPECTORS than any other Company, and can therefore more closely consult the convenience of clients.

Over 50,000 Boilers and Engines under supervision.

CONSULTING ENGINEERING. All other **INSURANCES** arranged.

J. F. L. CROSLAND, M. Inst. C.E., M.I. Mech. E., M.I.E.E., Chief Engineer.
JAMES M. DALE, Secretary. W1908

APPLICATIONS FOR AGENCIES INVITED.

WILLIAM BEARDMORE & CO.,

Limited,

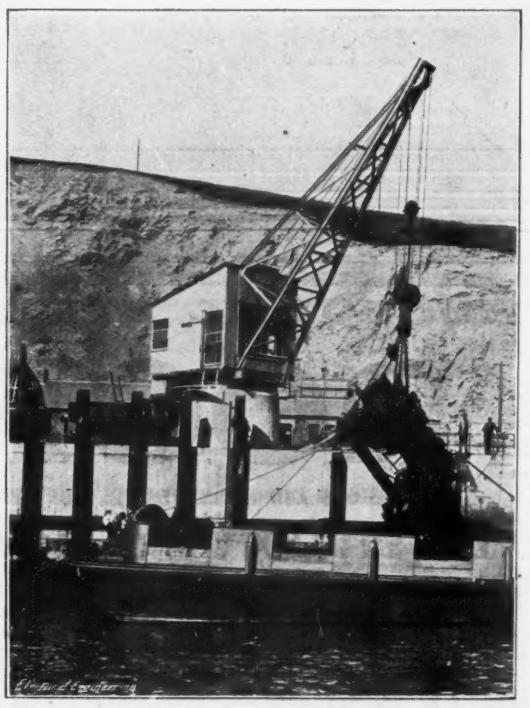
STEEL MANUFACTURERS

ARMOUR PLATE MAKERS,

FORGEMASTERS, SHIPBUILDERS & ENGINEERS

LATE E. NAPIER & SONS, (Ltd.), J8

GLASGOW.



Electric, Steam, AND Hand Cranes.

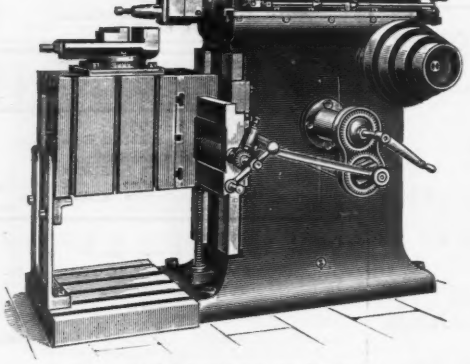
Electric Traversers, Capstans, &c.

Grabs, Concrete Mixers, &c. X1492

Fig. 916: Electric Coaling Crane.

STOTHERT & PITT, LTD., BATH.

SHAPERS.



18in. stroke Stationary Head Shaper.

With Stationary or Traversing Heads, and one or two tables, 6in. to 24in. stroke.

Large Stock of Lathes.

Drilling, Planing, Shaping, Slotting, Screwing, Punching and Shearing Machines, &c.

No. 152 CATALOGUE. Sections now ready.

Lathes. Shapers.

Drilling Machines.

Planing, Slotting & Screwing Machines.

Punching, Shearing and Bending Machines.

Z11

London Office—Norfolk House, Laurence Pountney Hill.

F. PRATT & CO., LTD., Eagle Ironworks, HALIFAX, ENG.

THE UNITED KINGDOM

SUITABLE FOR ALL TYPES OF STEAM ENGINES.

Supplied to the largest Railways and Engine Builders in the World.

Specially adapted for Refrigerating Machinery.

X1885

METALLIC PACKING AND PATENT LUBRICATOR.

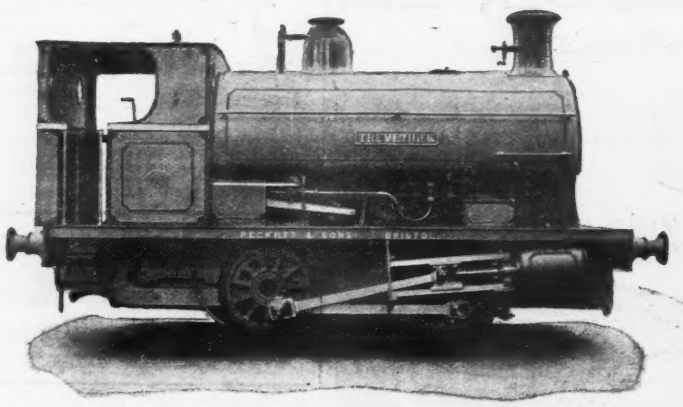
Is the Simplest and Most Durable Packing in the Market.

FIXED ON APPROVAL & GUARANTEED.

SEND FOR PARTICULARS TO

HEAD OFFICE: 14, COOK STREET, LIVERPOOL.

PECKETT & SONS, BRISTOL.



SPECIALITY

LOCO. TANK ENGINES

Of all descriptions and any Size or Gauge. A1848

Full particulars on application. Telegrams—PECKETT, BRISTOL.

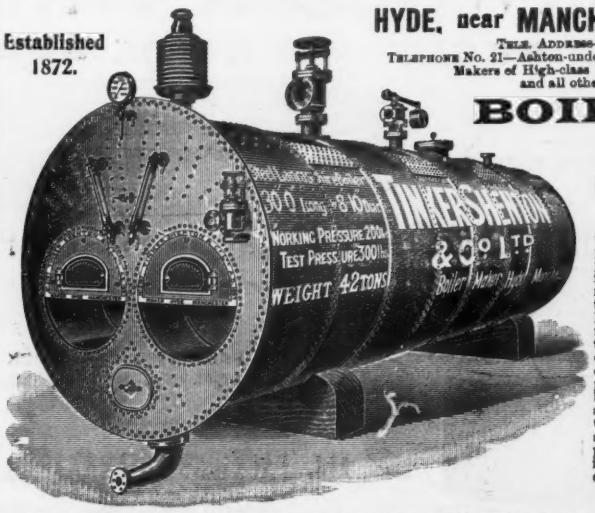
TINKER, SHENTON & CO., Ld.

Established 1872.

HYDE, near MANCHESTER.

Tele. Address—DUPLEX, HYDE
Telephone No. 21—Ashton-under-Lyne.
Makers of High-class Lancashire, Cornish, and all other Types of

BOILERS.



Contractors to His Majesty's Government

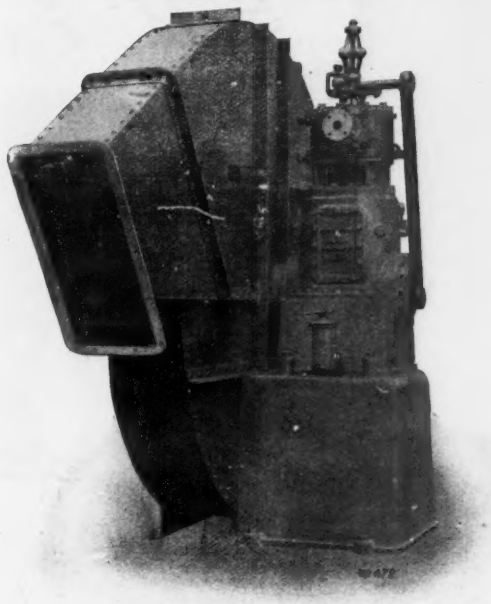
All holes drilled out of the solid plate, and the pitch of rivets set out by patent automatic dividing apparatus. Welding, flanging, planing, riveting, &c., by **Special Machinery** of the most modern construction. **Riveting** all done by hydraulic power constructed so that the pressure on the rivet can be regulated from 20, 50, and 80 tons, according to the diameter of the rivet, and the thickness of the plates. This is a most important feature in the construction of high-pressure boilers. X801

London Agents: W. H. Cochrane & Co., Suffolk House, 5, Laurence Pountney Hill, London, E.C.

HEENAN & FROUDE

Telegrams— HEENAN, WORCESTER. LIMITED. Telephone— No. 21 WORCESTER.

WORCESTER.



FANS { FORCED DRAUGHT, INDUCED DRAUGHT, MINE VENTILATION, AND ALL OTHER PURPOSES.

Bridges, Roofs, Constructional Work: NEWTON HEATH IRON WORKS, MANCHESTER.

Refuse Destructors: 4, CHAPEL WALKS, MANCHESTER.

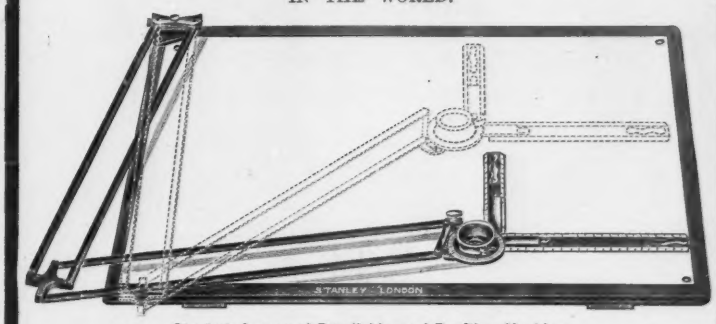
STANLEY,

LONDON.

LARGEST MANUFACTURERS OF

SURVEYING & DRAWING INSTRUMENTS

IN THE WORLD.



Stanley's Improved Parallel-braced Drafting Machine.

DRAWING OFFICE STATIONERY

Of all kinds at lowest prices. A very large stock kept.

Please send for our H 5 Catalogue (post free) and compare our prices with those of other first-class makers.

W. F. STANLEY & Co., Ld.

GREAT TURNSTILE,
HOLBORN, LONDON, W.C. C2

Showrooms - - 286, High Holborn, W.C.

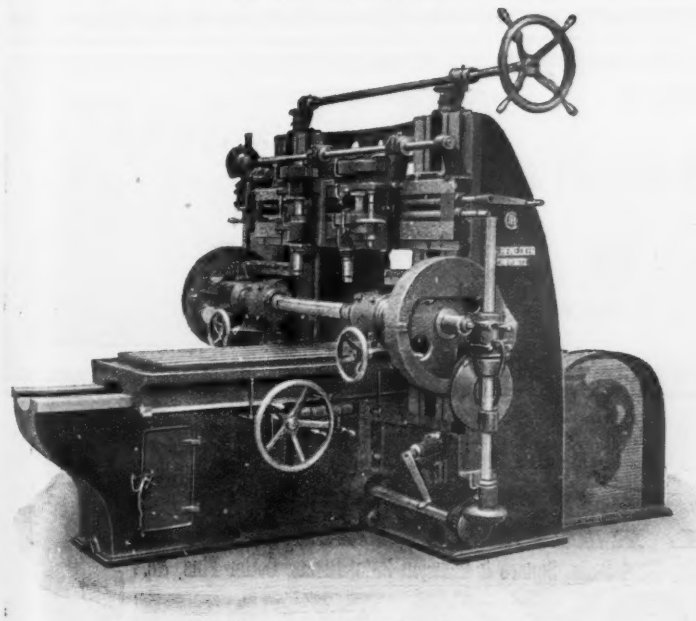
J. E. Reinecker, Chemnitz-Gablenz

MANUFACTURER OF

MACHINE & HAND TOOLS

Of Improved Design and Highest-class Workmanship for MACHINE MANUFACTURERS.

PARIS, 1900, GRAND PRIX.



Double-head Slab Mill, with 2 Vertical Spindles.

Specialities { RELIEVING LATHES FOR FORMED CUTTERS. PLANT for CUTTING RACKS, SPUR, BEVEL, SPIRAL & WORM GEARS

Catalogues free on application with Trade Card. Sole Agents for the United Kingdom— Y592

PFEIL & CO., 145-9, St. John Street, Clerkenwell, London, E.C.

Telegraphic Address—PFEIL, LONDON. Tele. Nos. 628 and 629 HOLBORN.

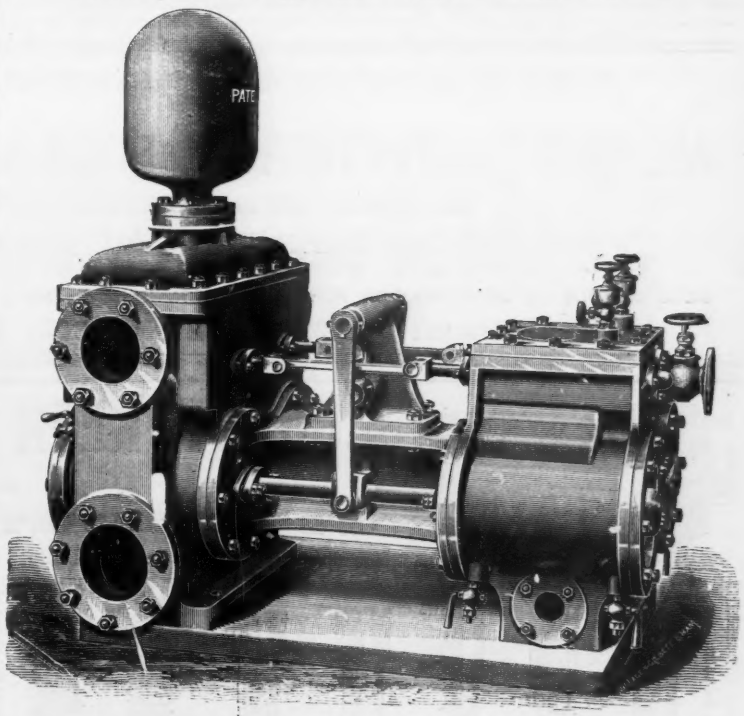
PUMPS & PUMPING PLANTS, STEAM or ELECTRIC DRIVEN

PATENT SLIDE VALVE UNCHOKEABLE

SHIPS' BALLAST PUMPS.

2000 IN USE.

CAPACITIES, 35—300 TONS PER HOUR.



CARRICK & WARDALE,

GATESHEAD. Q675

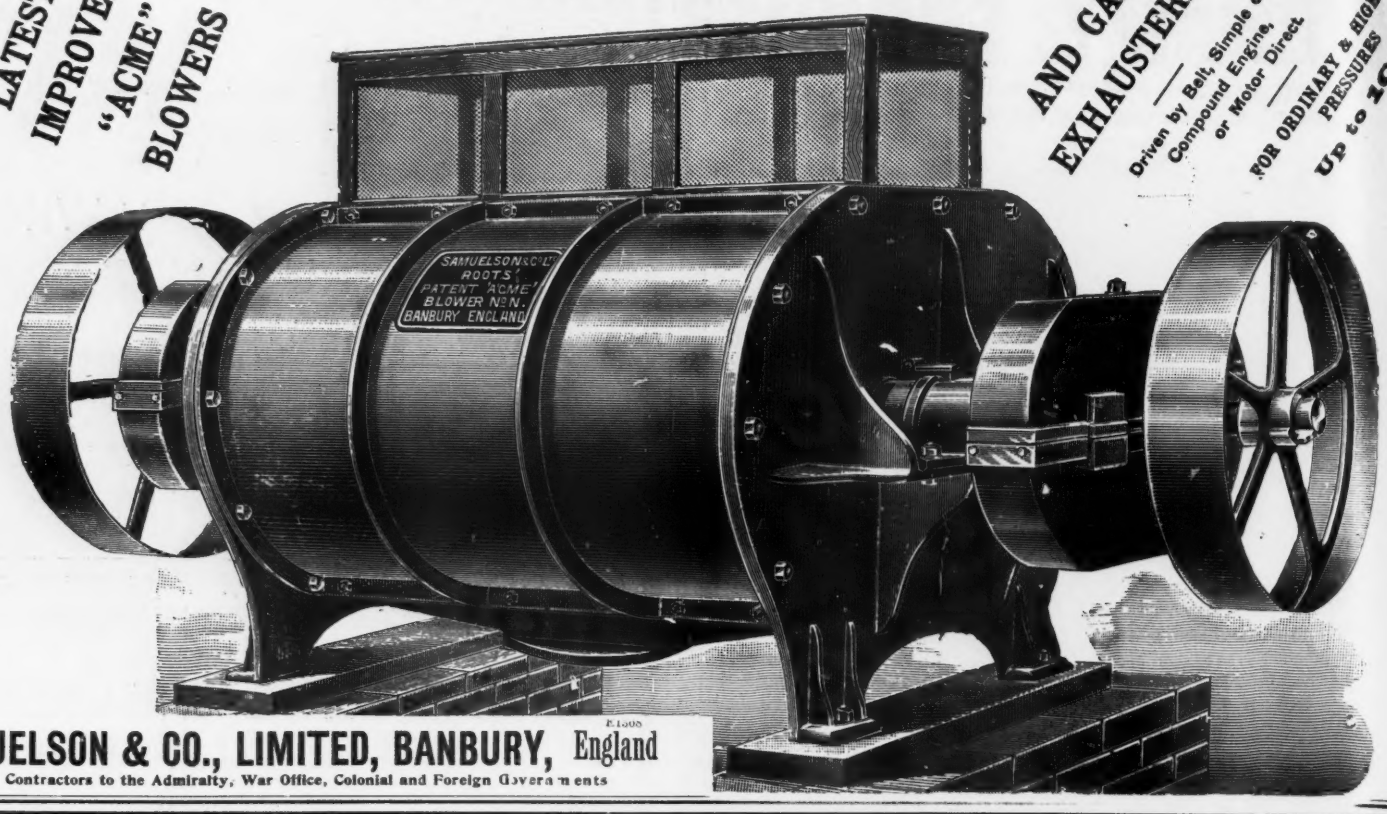
OVER 9000 MADE AND SOLD

ROOTS' LATEST IMPROVED "ACME" BLOWERS

AND GAS EXHAUSTERS

Driven by Belt, Simple or Compound Engine, or Motor Direct.

FOR ORDINARY & HIGH PRESSURES Up to 10 lbs.



SAMUELSON & CO., LIMITED, BANBURY, England

Contractors to the Admiralty, War Office, Colonial and Foreign Governments

A. RANSOME & CO., LTD., NEWARK-ON-TRENT, ENGLAND.

Manufacturers of WOOD-WORKING MACHINERY.

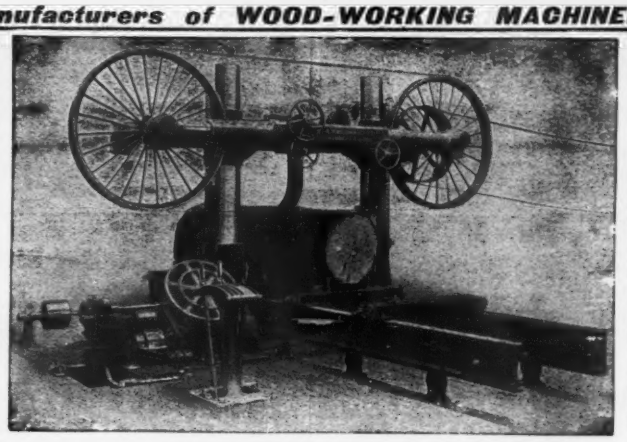
Telegraphic Addresses—
RANSOME, NEWARK.
RANSOME, LONDON.

RANSOME'S Patent HORIZONTAL

LOG BAND SAW

is by far THE MOST RAPID, ACCURATE and ECONOMICAL Log-Sawing Machine IN THE WORLD, and is free from unnecessary complications.

No Saw Mill is up to date without these Machines.



Capable of producing the highest grade of work.

LONDON OFFICE—
63, QUEEN VICTORIA ST., E.C.

These Machines are made in Four Sizes to take logs up to 6ft. in diameter, and are now working in various parts of the World.
Between 30 and 40 of them can be seen in operation in some of the leading Timber Yards in this Country.

RANSOME'S PATENT LOG BAND SAW will do as much work as a VERTICAL LOG FRAME, RACK CIRCULAR SAW BENCH and RECIPROCATING FRAME COMBINED, economising more than half the power, floor space, and labour required to work the above three machines.

Write to Dept. B for Pamphlet describing this Machine, with Testimonials, post free on application. N2

THE PRODUCTION & MANUFACTURE
OF
ALL WHITE ANTI-FRICTION METALS & TIN ALLOYS
IS THE SPECIALITY OF
THE TANDEM SMELTING SYNDICATE, LTD.

SEND SAMPLE OR SPECIFICATION FOR QUOTATION. NO CHARGE FOR ANALYSIS

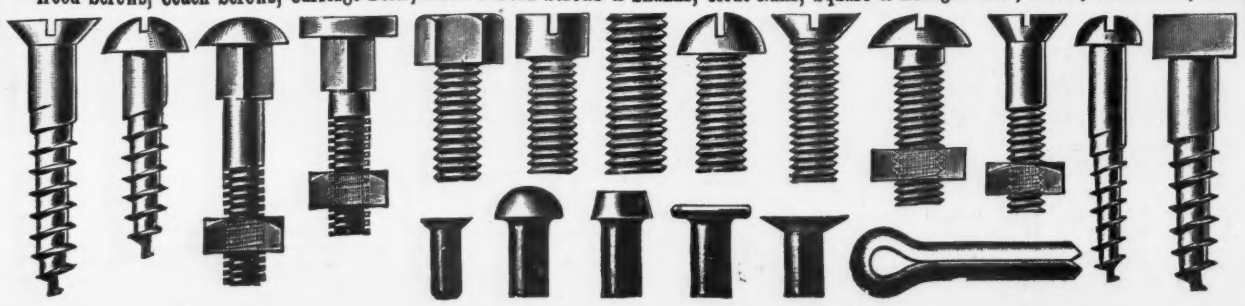
Address: MERTON ABBEY, LONDON, S.W. 849

GUEST, KEEN & NETTLEFOLDS, LD.

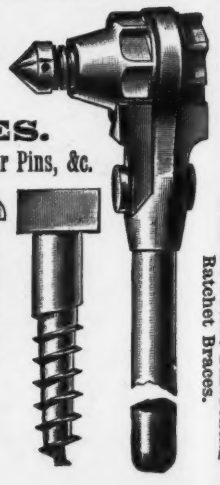
MANUFACTURERS OF BIRMINGHAM.

WESTON'S DIFFERENTIAL RATCHET BRACES.

Wood Screws, Coach Screws, Carriage Bolts, Metal Thread Screws & Shanks, Clout Nails, Square & Hexagon Nuts, Rivets, Cotter Pins, &c.



Weston's Patent Differential Ratchet Braces.



Weston's Patent Differential Ratchet Braces.

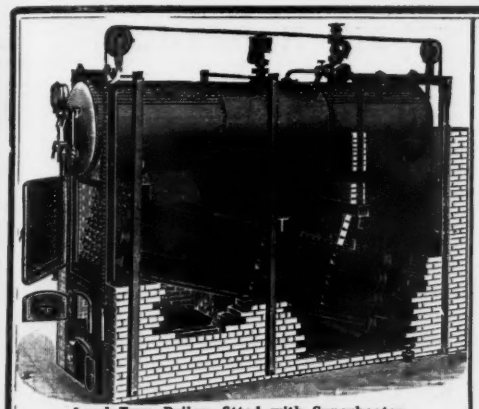
"PREMIER" GAS ENGINES ARE IN USE IN ALL PARTS OF THE WORLD.

FOR . . .
ELECTRIC POWER
(TRACTION AND LIGHTING)
MILL DRIVING
ROLLING MILLS
BLAST, &c. &c.

ADVANTAGES . . .
RELIABILITY, SIMPLICITY.
QUIET AND STEADY RUNNING.
LOW REPAIRS AND COSTS.

THE PREMIER GAS ENGINE CO.
Limited,
SANDIACRE, near NOTTINGHAM. Q197

View of Two Large "PREMIER" TANDEM ENGINES Installed at LA PAZ for the BOLIVIAN GOVERNMENT RAILWAYS. These Engines are working at an altitude of over 12,000ft. above sea level Probably the most elevated power station in the world



Land Type Boiler, fitted with Superheater.

OVER 6,500,000 H.P. (Land Type) IN USE
IN ALL INDUSTRIES.
Fired with all kinds of Fuel.

BABCOCK & WILCOX LIMITED
PATENT WATER-TUBE BOILERS.

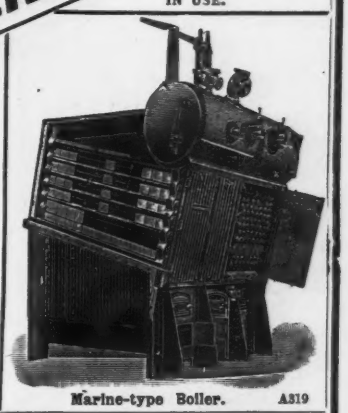
BABCOCK & WILCOX ALSO MANUFACTURE:—
STEAM SUPERHEATERS.
MECHANICAL STOKERS.
FEED-WATER HEATERS.
WATER SOFTENERS & PURIFIERS.
STEEL CHIMNEYS.
COAL CONVEYORS.
STRUCTURAL STEEL WORK.
ELECTRIC CRANES.
STEAM PIPING PLANTS.

ORIEL HOUSE,
FARRINGDON ST.,
LONDON, E.C.
Works - RENFREW, SCOTLAND.

Estimates Free. Send for Catalogue.

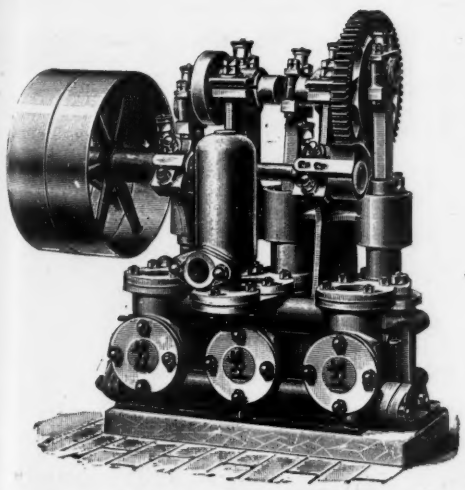
Telegrams—BABCOCK, LONDON. Telephone Nos.—5540, 5541, 5542 & 5543 HOLBORN.

1,300,000 H.P. (Marine Type) IN USE.



Marine-type Boiler. A319

VERTICAL PLUNGER PUMPS



300 FEET HEAD PATTERN

For BELT & ELECTRIC POWER.

All Sizes in Stock for Immediate Delivery.

Telegrams—"EVANS," WOLVERHAMPTON. Telephone—NATIONAL No. 39.

LONDON OFFICE—SALISBURY HOUSE, LONDON WALL, E.C.

WRITE FOR LISTS TO—

JOSEPH EVANS & SONS

Q85

CULWELL WORKS,

WOLVERHAMPTON.

HEAD, WRIGHTSON AND CO., LTD.

CONSTRUCTIONAL ENGINEERS, IRON FOUNDERS AND BRIDGE BUILDERS.

Works :—

TEESDALE IRONWORKS, **THORNABY**-on-Tees.

STOCKTON FORGE, **STOCKTON**-on-Tees.

EGGLESCLIFFE FOUNDRY, **STOCKTON**-on-Tees.

Telegrams—"Teesdale, Stockton-on-Tees."

Bridge over River Spey, Highland Railway.

Specialities :

BRIDGES, VIADUCTS, ROOFS.

BLAST FURNACE PLANT.

STRUCTURAL IRON and STEEL WORK.

Dock Gates. Caissons.

Pithead Frames. Colliery Plant.

Cast-Iron and Steel TANKS.

GAS PLANT. Q587

COWANS, SHELDON & CO., LTD., CARLISLE.

Telegraphic Address—ST. NICHOLAS, CARLISLE.
A B C and A1 CODES USED.

MASTING SHEERS.

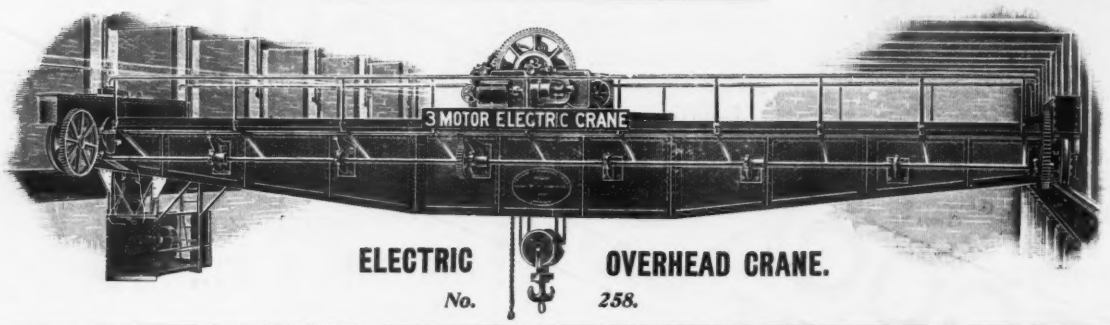
Turntables.

CAPSTANS.

Heavy LIFTING PLANT a Speciality.

ELECTRIC, HYDRAULIC, STEAM, & ROPE-DRIVEN

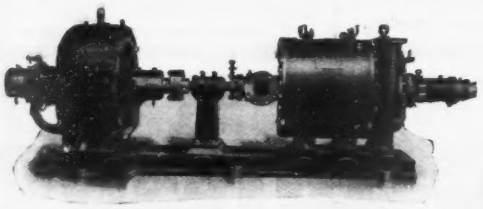
CRANES.



ELECTRIC OVERHEAD CRANE. *No. 258.*

HIGHEST EFFICIENCY.

Any Capacity and He For Belt or Direct Drive.



6-STAGE ELECTRICALLY-DRIVEN CENTRIFUGAL HIGH-LIFT PUMP.

For 500ft. to 700ft. Head.

"BON-ACCORD" HIGH LIFT CENTRIFUGAL PUMPS

also LOW-LIFT CENTRIFUGAL PUMPS.

HIGH-SPEED ENGINES. FAN ENGINES.

DRYSDALE & CO., LTD., Bon-Accord Works, GLASGOW.

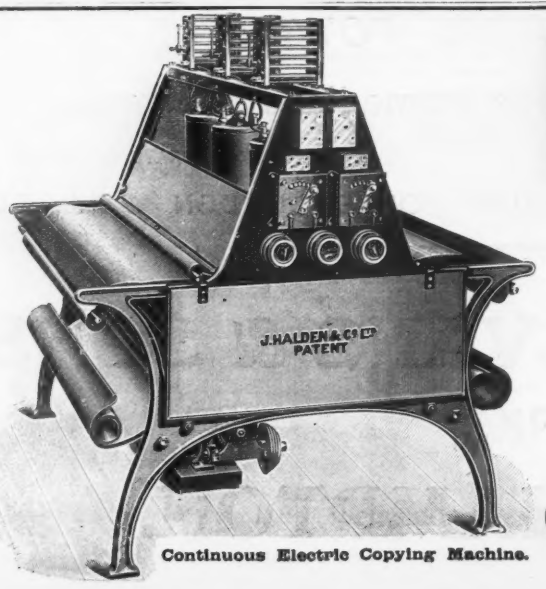
Telegrams—BONACCORD, GLASGOW. WRITE for CATALOGUE. X1915

MAKERS OF

PUMPING PLANT

FOR

DOCKS, IRRIGATION, DRAINAGE, SEWAGE, SAND DREDGING, CIRCULATION and WRECKING PURPOSES.



Continuous Electric Copying Machine.

HALDEN'S

FOR

ELECTRIC PHOTO. COPYING MACHINES,
ENGINEERS' PHOTO. PAPERS and CLOTHS,
DRAWING MATERIALS and INSTRUMENTS,
PERMANENT BLACK LINE PHOTO. COPIES,
EVERYTHING FOR THE DRAWING OFFICE Q52/

J. HALDEN & Co., LTD., 8, ALBERT SQUARE, MANCHESTER.

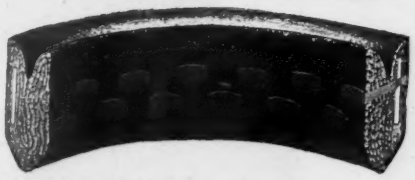
LONDON, NEWCASTLE-ON-TYNE, BIRMINGHAM, GLASGOW, and LEEDS.

IMPORTANT TO ENGINEERS!—A Thin Red Line, which is fully protected by Copyright, now runs through all **Genuine** "Lion" (Patent) **Gold** Prize-Medal **PACKINGS.** Also there are **Brass** Trade Mark Labels attached, without which **None** are genuine. **Beware of Imitations!**—Please observe that where a **White** line is shown in the illustration "The Thin Red Line" will be found in the Packing. **LOOK FOR "THE THIN RED LINE!"**

"LION" (PATENT) METALLIC "BLOCK" PACKING.

FOR GENERAL USE.
ALL Pressures, STEAM and WATER.

"LION" (PATENT) METALLIC "EXPANDING" PACKING.



FOR DIFFICULT WORK.
HIGHEST Pressures, STEAM and WATER.

"LION" (PATENT) METALLIC "AUTOMATIC" PACKING.

FOR PUMPS an HYDRAULIC WORK.

Sole Patentees and Manufacturers: **JAMES WALKER & CO., "Lion" Works, Garford Street, West India Docks, LONDON, E.**
Telegrams—"Lioncelle, London. T2 Telephone—3684 East.

CUNDALL'S SUCTION GAS PLANT

AND

GAS PRODUCER PLANT.

50 H.P. costs under 5d. per hour. Larger and smaller engines at the same rate. ***Sizes—15 to 300 H.P.***

THE "CUNDALL" PATENT OIL ENGINE.

The most popular Oil Engine, in use in all Countries.

CUNDALL, SONS & CO.,
Limited,
SHIPLEY, YORKS.

Telegrams—Cundall, Shipley.
Telephone—No. 4 Shipley.

London Office & Showrooms—
20-22, St. Bride St.,
E.C.

Q554

The Powerful **HYDRAULIC PRESSES** of the

PHŒNIX FOUNDRY CO., LTD., DERBY,

Turn out expeditiously **ALL KINDS OF PRESSED WORK.**

Segmental Steel Underbridges and **Culvert Pipes** to 102 inches diameter, Hobson and other **Bridge** and **Warehouse Flooring** up to 30ft. long, and their economical Combined Self-sustaining **Gutter Girders** and **Roofing,** saving Joists, Columns and Cast Gutters.

SEND FOR SECTION LIST. D7

A. G. MUMFORD,

ENGINEERS. LIMITED.

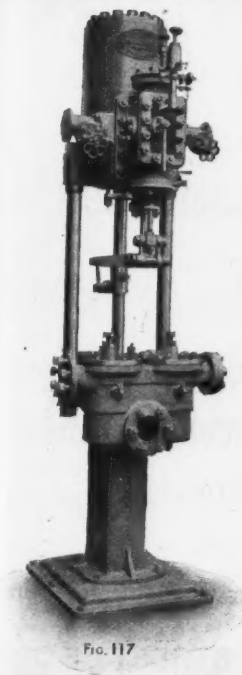


Fig. 117
BOILER FEED PUMP.

VERTICAL DIRECT-ACTING

SIMPLEX PUMPS

Fitted with Mumford & Anthony's Patent Valve Gear.

Boiler-Feed, Ballast and Air Pumps

SIMPLE or COMPOUND.

Reliable, Efficient and Economical for MARINE or LAND PURPOSES, ELECTRIC LIGHT STATIONS, &c. O1505

ON ADMIRALTY LIST.

Full particulars and prices for Pumps for all duties—

CULVER STREET ENGINEERING WORKS, COLCHESTER.

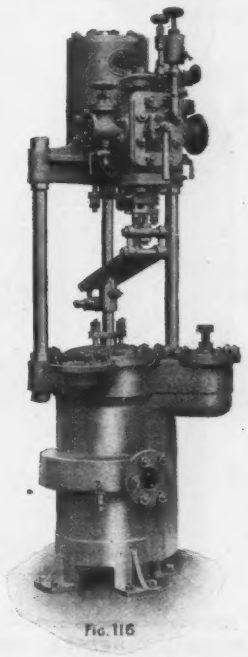


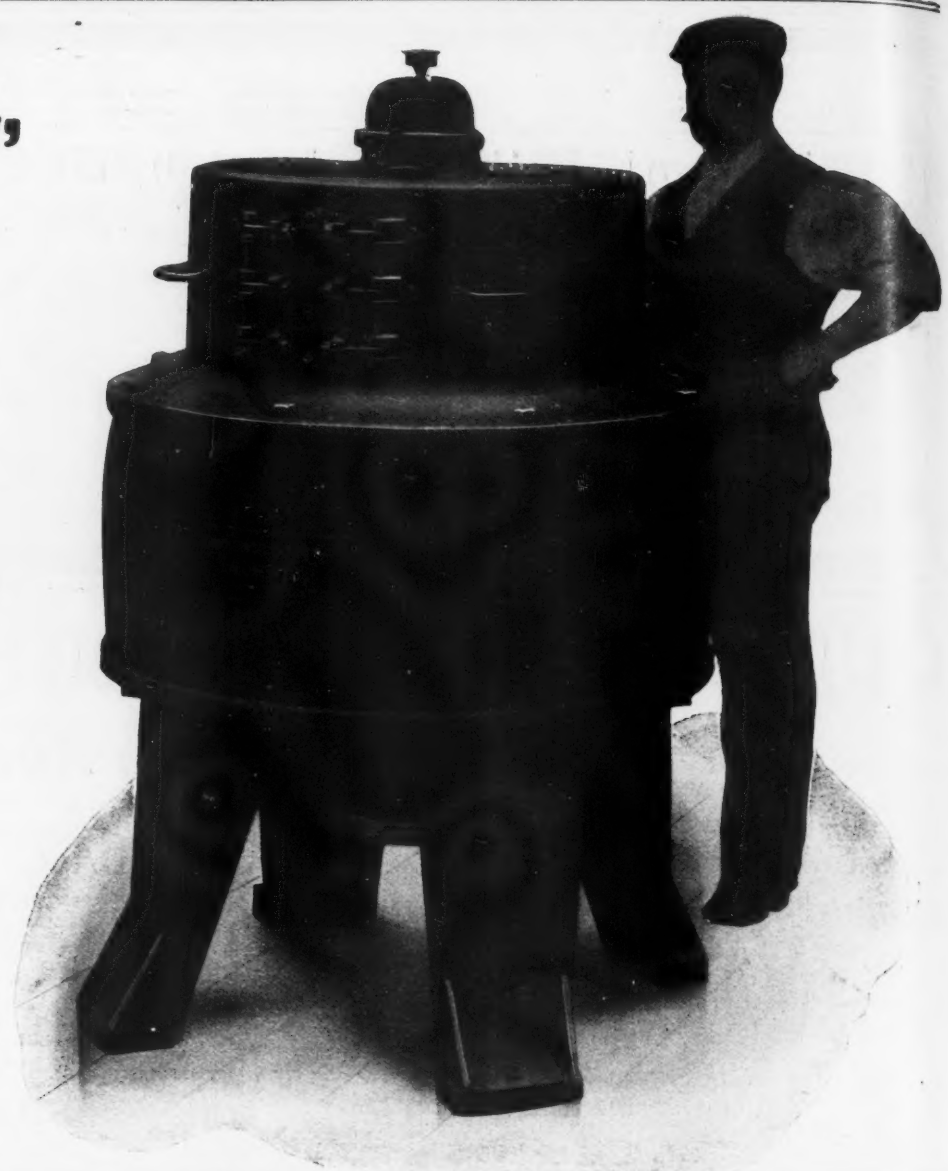
Fig. 116
AIR PUMP.

LAURENCE, SCOTT & CO., Ltd.,

NORWICH,

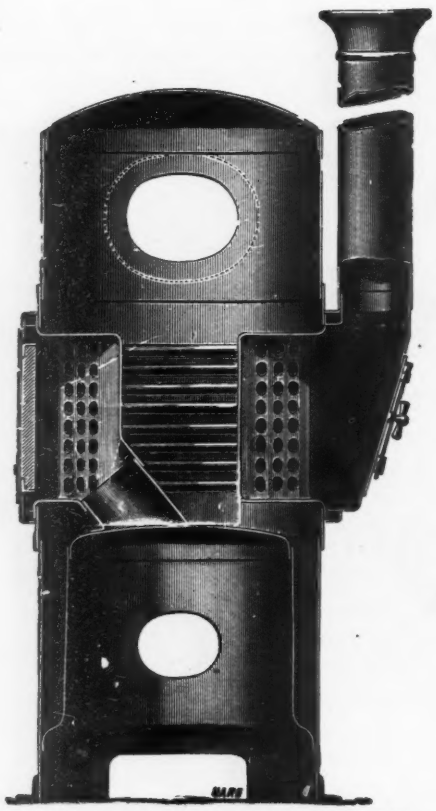
NORFOLK.

Established 1884.



DAVEY. PAXMAN & CO. LD.

COLCHESTER, England.



PAXMAN'S "ESSEX PATENT VERTICAL TUBULAR BOILER.]

PAXMAN'S "ESSEX" PATENT VERTICAL TUBULAR BOILER.

Occupies little space. *Tubes easily withdrawn.*

MOST ECONOMICAL & EFFICIENT

IN ALL SIZES and FOR ALL PRESSURES.

Large Numbers of these Boilers have been supplied

For LAND PURPOSES, STEAM LAUNCHES, &c

MAKERS ALSO OF

CROSSTUBE VERTICAL, LOCOMOTIVE, LANCASHIRE, CORNISH,

WATER-TUBE, MARINE, EXTERNALLY-FIRED & PAXMAN'S "ECONOMIC" BOILERS

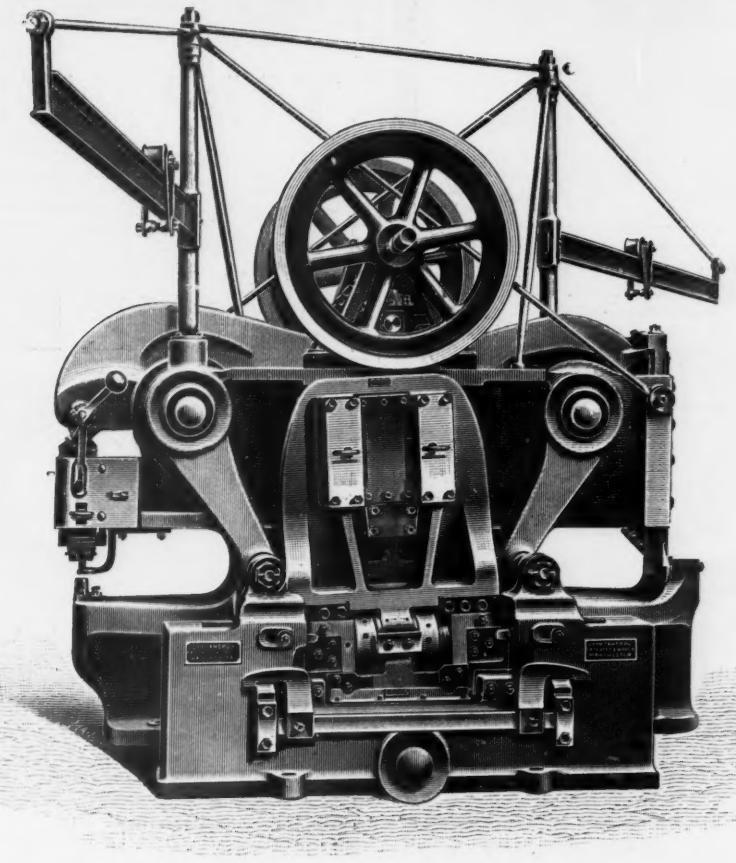
PAXMAN'S PATENT INDEPENDENTLY-FIRED SUPERHEATERS.

Telegraphic Address: "PAXMAN, COLCHESTER." 01164

London Office - - 78, QUEEN VICTORIA STREET E.C

CAMERON'S

PATENT MACHINE FOR CUTTING ZEDS, ANGLES AND BULBS, WITHOUT CHANGING KNIVES.



COMBINED WITH PATENT CAM & LEVER PUNCHING AND SHEARING MACHINE.

JOHN CAMERON, Limited, Oldfield Road Ironworks, SALFORD, G724a MANCHESTER

MORTON PNEUMATIC RIVET FURNACE.

MORTON Portable

PNEUMATIC

RIVET FURNACE.

Coke Fuel

Great Capacity.

Most Economical.

WRITE FOR SPECIAL CIRCULAR.

PNEUMATIC TOOLS

OF ALL KINDS.

COMPLETE NEW CATALOGUE

UPON APPLICATION.

THE GLOBE PNEUMATIC ENGINEERING CO., LTD.,

150, Queen Victoria Street, LONDON, E.C.

Branch Offices: MILBURN HOUSE, NEWCASTLE-ON-TYNE; 156, ST. VINCENT STREET, GLASGOW.

HOME AGENCIES:
MANCHESTER—C. S. DRAKE, 16, John Dalton Street.
BIRMINGHAM—G. D. DAUNCEY, 45, Newhall Street.
LIVERPOOL—R. DUDLEY WOOD, 14, Dale Street.
SWANSEA—ATKINSON & CO.
DUDLEY—HARPER & SONS.
LEEDS—GEO. DEPLEDGE & CO., King Street.

COLONIAL AND FOREIGN AGENCIES
PARIS—H. HAMELLE, 21-23, Quai de Valmy.
BERLIN—ALLGEMEINE PRESSLUFT GESELLSCHAFT.
MILAN—DEPOSITO POMPE WORTHINGTON, Via Dante, 4.
ST. PETERSBURG—GREGOIRE WEINBERG & CO Nevsky, 47—1
JOHANNESBURG—WM. BLANE, M.E., Permanent B ildings.
TOKYO—YONEI SHOTEN, 12 Nichome Cho, Ginza.
MONTREAL—MUSSENS, LTD.
SYDNEY—H. C. STANLEY.
WELLINGTON, N.Z.—RILEY & HOLMES.

248

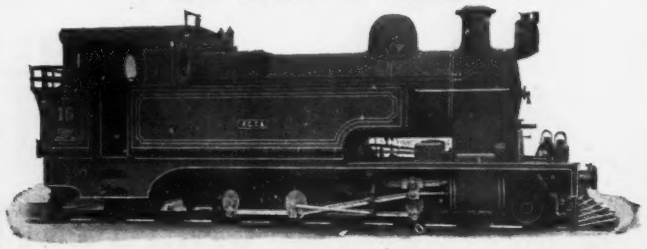
ESTABLISHED 1837. 2 GRANDS PRIX, PARIS, 1900; MILAN, 1906.

A. BORSIG,

TEGEL.

HIGH-GRADE SINGLE EXPANSION & COMPOUND LOCOMOTIVES

ADAPTED TO EVERY VARIETY OF SERVICE.



Combined Rack and Adhesion Locomotive for Transandine Rly. (2—6—2 type)

Oldest Locomotive Works on the Continent. Modern Shops. Latest Designs Over 12,000 Workmen. 6500 LOCOMOTIVES BUILT. Annual Capacity, 500 Locomotives.

London and District Enquiries to: ROBERT WEATHERBURN, M.I. Mech. E., Finsbury Pavement House, London, E.C.

Provincial Enquiries to: C. KORTE, Standard Buildings, 38, Park Row, Leeds.

Having WON its WAY by MERIT, and TRIUMPHED on the TIME TEST,

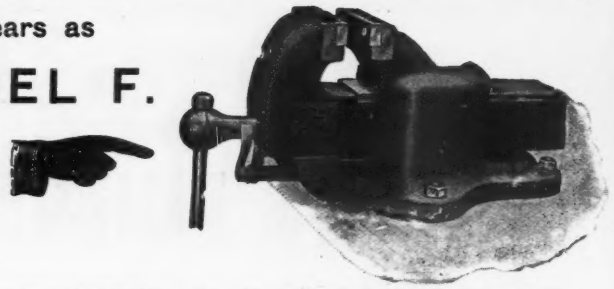
THE **"PERFECT" VISE**

in principle **UNCHANGED,**

in construction **IMPROVED,**

appears as

MODEL F.



ADVICE TO BUYERS.—Specify "Perfect" Vise, Model F.

J. PARKINSON & SON, Shipley, Yorks. Q457

BOILERS

Of all Types.

Very Best Material and Workmanship.

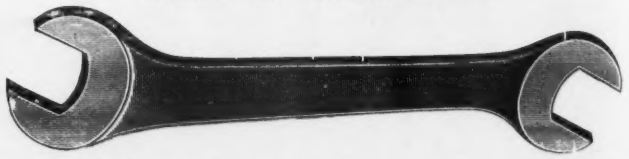
E. R. & F. TURNER, Ltd.

St. Peter's Works (114), IPSWICH, ENGLAND.

SOLID DROP FORGED STEEL

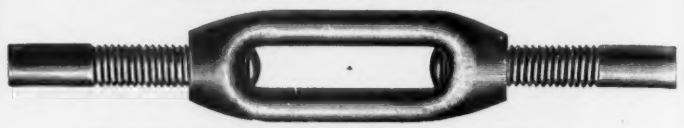
SPANNERS

DOUBLE OR SINGLE ENDED.

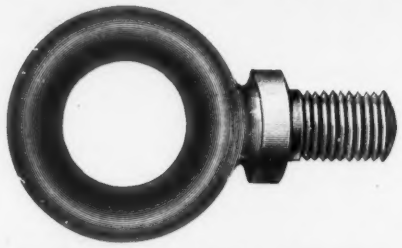


TURNBUCKLES

WITH OR WITHOUT STUB ENDS.



EYEBOLTS



ALL LEADING SIZES SUPPLIED FROM STOCK.

ALL LEADING SIZES SUPPLIED FROM STOCK.

ARMSTRONG, STEVENS & SON,

Whittall Street, BIRMINGHAM.

ROOFS OF EVERY DESCRIPTION PLAIN OR ORNAMENTAL **TRUSSES**

MEASURES Bros. Ld. 56b, SOUTHWARK ST., LONDON, S.E. Telephone Nos.— 586 Hop. 9492 Central. & PITLAKE, CROYDON Telephone No. 171 Croydon.

DESIGNS FREE TIE RODS IN STEEL SHOES &c OR IRON ESTIMATES FREE

SPECIAL DESIGNS FOR **CHURCHES** &c. DESIGNS & ESTIMATES FREE.

STEEL PLATES & CHEQUERED FLOORS

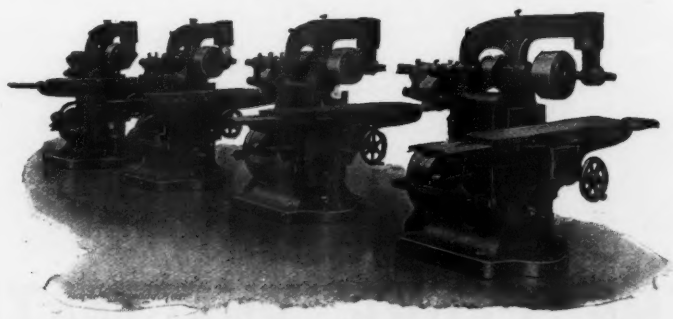
Steel Shafting from 2½in. to 8in. dia. and up to 36ft. long always kept in stock.

- AUTOMATIC -

Surface Grinding Machines

FOR RAPID AND TRUE WORK ARE UNEQUALLED.

These Labour-saving Machines are indispensable for locomotive and other engine work; also for engineering work generally requiring true surfaces.



GRINDING AND POLISHING MACHINERY

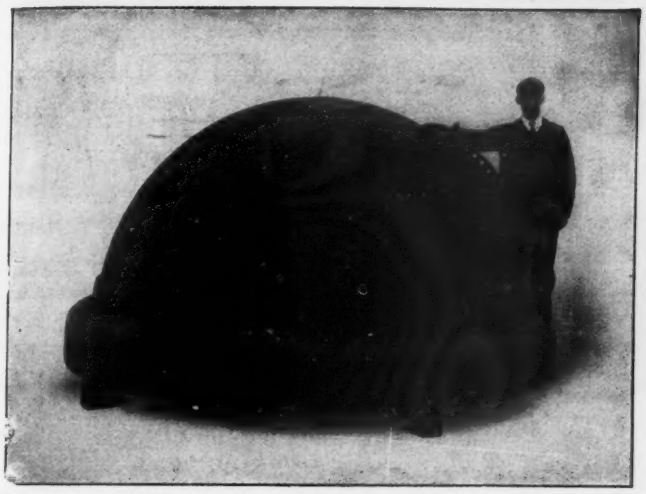
of the most modern designs.

EMERY AND CORUNDUM WHEELS

LUKE & SPENCER, LTD.,

Navigation Works, Broadheath, MANCHESTER. K9

COCHRAN BOILERS.



PATENT SEAMLESS FURNACE, as fitted to large Cochran Boiler.
Pressed from One Plate. No Rivetted Seams Exposed to Flame.

COCHRAN & CO., ANNAN, LTD.,
ANNAN, SCOTLAND.

Telegrams—"WEDGE, LEEDS. "LOCKENCAN, LONDON." Telephone—Leeds 506; London, Holborn, 1847.

To Locomotive and Railway Carriage Superintendents.

KAYE'S Patent Automatic Carriage Door Wedge Lock, with or without inside Handle).
KAYE'S Patent Safety Catch.
KAYE'S Patent Outside Handle, made to any pattern.
KAYE'S New Patent for Automatically fastening Sliding Doors, Corridor Carriages or Tram Cars.

After many years' trial a good demand has been made for Kaye's Patent Wedge Locks, and reference may be made to the following Railway Companies, viz., Great Eastern, North-Eastern, Great Northern, London & South-Western, South-Eastern & Chatham, Lancashire & Yorkshire, Great Central, the Furness Railway, &c.

Apply for Samples and further particulars to the Sole Makers,

Joseph Kaye & Sons, LTD.,

93, HIGH HOLBORN,
LONDON, W.C

Works HUNSLET, LEEDS.

A. EDMESTON & SONS

Note New Address—CAWDOR STREET, PATRICROFT.

PATENT FRICTION CLUTCH.

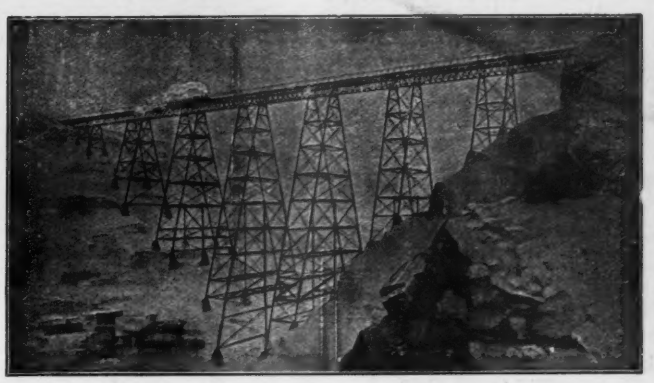
SEND FOR PRICE LIST AND DESCRIPTION. X1468

The HORSELEY CO., Ltd.,

Engineers, TIPTON, STAFFORDSHIRE.

London Office: 11, VICTORIA STREET, WESTMINSTER, S.W. Passenger Station, Dudley Port.
Works and Head Offices: TIPTON, STAFFORDSHIRE, ENGLAND.
Telegraphic Addresses—HORSELEY, TIPTON; GALILEO, LONDON.

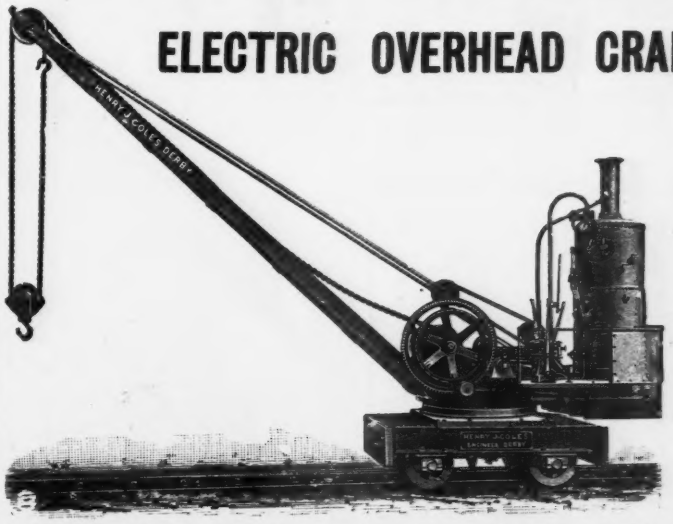
Ironfounders and Manufacturers of Structural Iron and Steel Work



BUILDERS OF **Bridges, Piers, Viaducts, and Roofs**
FOR THE ENGLISH, COLONIAL, & INDIAN RLYS. U1964
Gas Plant, Cast Iron and Steel Sashes, &c.

STEAM CRANES.

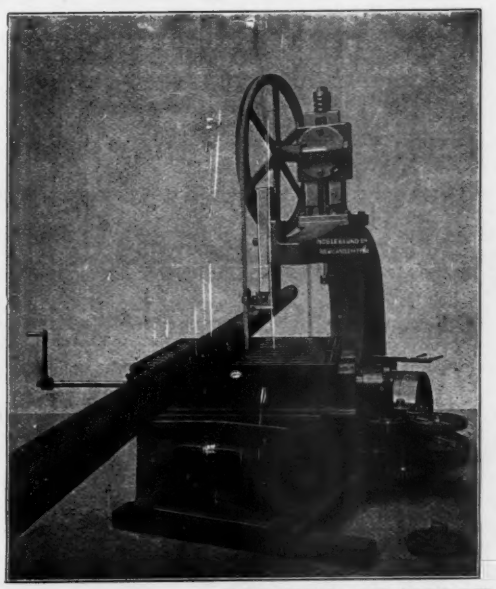
ELECTRIC OVERHEAD CRANES



HENRY J. COLES, Ld., London Crane Works, Derby

NOBLE & LUND, LTD.,

FELLING-ON-TYNE, ENGLAND.



PATENT BAND SAWING MACHINES

For CUTTING IRON and STEEL COLD.

OVER 900 SOLD.

MADE IN SEVERAL SIZES.

ALWAYS IN STOCK. A19

This machine will cut through bars, joists, &c., of any length, at right angles to the bar at one operation, and thus increases the usefulness of the machine.

Representative for Scotland—A. J. KINGHORN, 59, Robertson St., GLASGOW.

ALL LEADING SIZES SUPPLIED FROM STOCK.

DAVY BROS., L[D].

SHEFFIELD.

Telegrams—Motor. Telephone—44, 2430, & 2416.

COMPRESSION OF STEEL INGOTS.
(Robinson and Rodgers' Patents.)

RAPID-ACTION FORGING PRESSES.

LANCASHIRE BOILERS.

INDUCED & BALANCED DRAUGHT with Hot Air Economiser.
(Ellis and Eaves' Patents.)
FOR ALL LAND TYPE BOILERS.

STEEL WORKS PLANT

See Illustrated Advertisement on Dec. 6th, 1907, and on Jan. 3rd, 1908 Q978

SCREWING MACHINES
FOR
PIPES to 12in. dia. BOLTS to 4in. dia.
SCREWING TACKLE
of every description.
See Larger Advt. in Future Issues. Q580
WILLIAMSON, Brownsfield Mills, Manchester

Werf GUSTO, Firma A. F. Smulders,
SCHIEDAM, HOLLAND.
SPECIALITY—
DREDGING & EXCAVATING PLANT
See our advert. every fourth week.

RAILS! RAILS!! RAILS!!!
SEND YOUR ENQUIRIES FOR
RAILS, ACCESSORIES, AND WAGONS

TO
MARPLE & GILLOTT, Ltd.,
Iron and Steel Merchants,
Manufacturers' Constructional Ironworks,
Coronation Bldgs., Attercliffe Rd., SHEFFIELD
Telephone 1342. Teleg., Ferric, Sheffield' Z104

THE GLASGOW STEEL ROOFING CO., LTD.
Telegrams—Roofing, Glasgow.
Designers, Manufacturers, and Exporters of
STEEL-FRAMED ENGINEERING SHOPS,
SHIPYARD BUILDINGS,
BOILER HOUSES, RAILWAY STATIONS,
TRANSIT SHEDS, & BUILDINGS
FOR ALL INDUSTRIAL PURPOSES.
xm36
Head Offices: POSSILPARK, GLASGOW.

GLOBE GAS ENGINE CO., LD.,
JOHNSTONE, N.B.
Makers of *GAS & OIL ENGINES* and *SPECIAL MACHINE TOOLS.*
Q430
SEE ADVT. IN ISSUE OF DEC. 6.

ENTWISLE & CASS, Ld
Engineers, BOLTON.
For CENTRIFUGAL PUMPS, AIR COMPRESSORS, CLUTCHES, GEARING, CASTINGS up to 10 TONS.
Z354

THORNTON & CREBBIN, Ltd.
Engineers & Ironfounders,
BRADFORD.
CASTINGS FOR THE TRADE:
FINISHED OR IN THE ROUGH
Up to Fifty Tons. Q605

PULLEYS.

Spring, Solid, or in Halves.

Shafting, Couplings, &c. &c.

Wood-work Machinery.

MACKIES LIMITED,
W1078
Caversham Road. READING

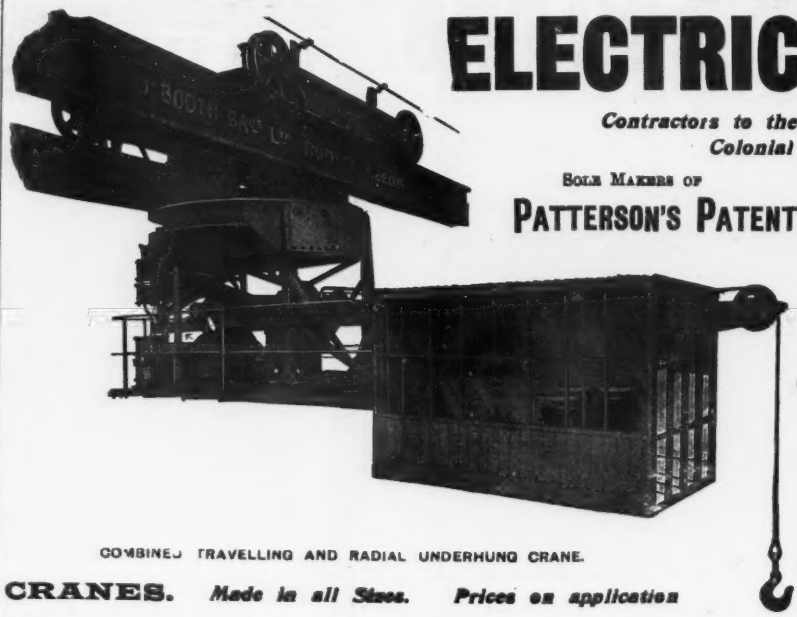
Patent Controllable Superheaters.
Patent Heat Accumulator Superheaters.
HIGHEST EFFICIENCIES.
Cruse Controllable Superheater Co.
5, BLACKFRIARS STREET, MANCHESTER. Q561

Telegrams—CRANES, RODLEY.

SPECIALITY

ELECTRIC CRANES.

Contractors to the War Office, Admiralty, & Colonial Governments.



COMBINED TRAVELLING AND RADIAL UNDERHUNG CRANE.

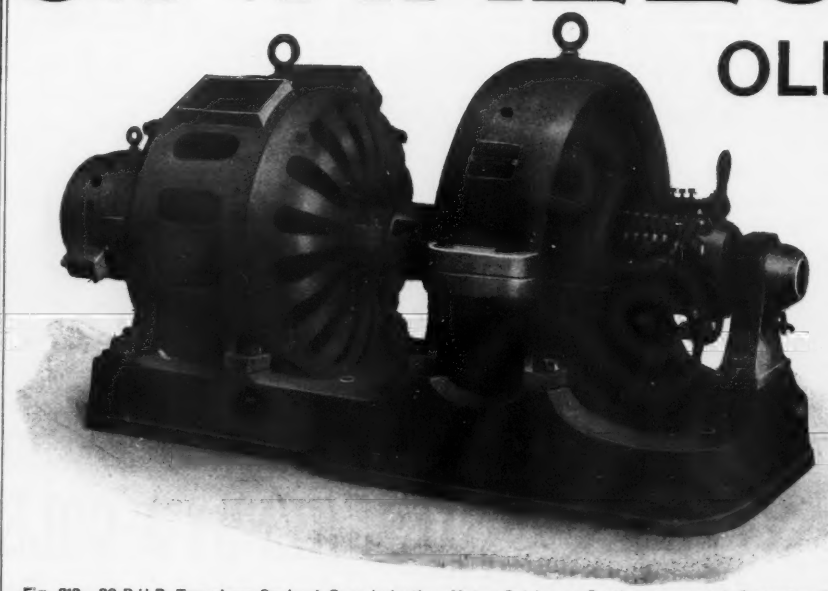
Sole Makers of
PATTERSON'S PATENT CHARGING MACHINE.
For Open-Hearth and Heating Furnaces.
PATENTED IN ENGLAND, AMERICA, AND GERMANY.

CANTILEVER, OVERHEAD, LOCOMOTIVE, GOLIATH, DERRICK CRANES, WINDING ENGINES, AND MOTOR AND ELECTRICAL EQUIPMENT, &c.

CRANES. *Made in all Sizes. Prices on application*

JOSEPH BOOTH & BROS., L[D].
RODLEY, LEEDS, ENG.
B1216

J. P. HALL & Co.,
OLDHAM.



TELEPHONE 300.
TELEGRAMS—DYNAMO.

Electrical Machinery
OF EVERY DESCRIPTION.

MOTORS for CRANES
a Speciality.

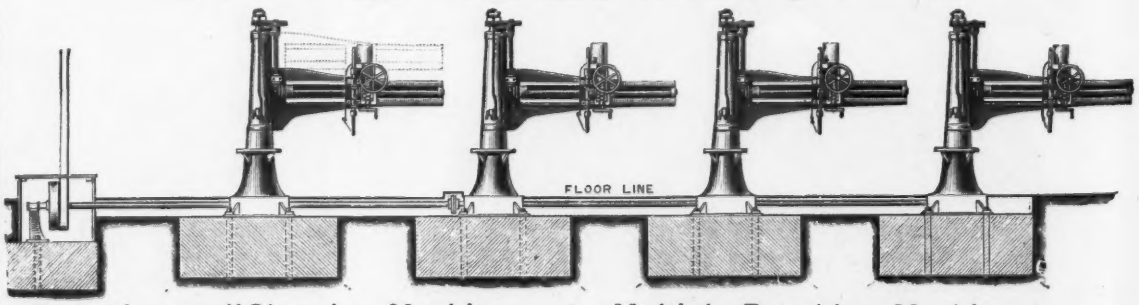
EXPORT TRADE receives special attention.
X1652

Fig. 319.—80 B.H.P. Two-phase Squirrel Cage Induction Motor Driving a Continuous-current Generator for supplying Continuous-current to Crane Motors. Squirrel Cage Motor on same shaft to act as Starter.

Radial Arm Drilling Machines.

For GIRDER WORK, &c., in Groups of 4 or more Drills, placed 10ft. apart.

These Drills are driven by a shaft running below the floor, so as to present no obstacle to the use of cranes overhead. Any drill can be stopped or started instantly without interfering with the others.



Punching and Shearing Machines.
Rivet Making Machines.
Plate Bending Machines.
Pneumatic Rivetting Machines.

Multiple Punching Machines.
Plate Edge Planing Machines.
Angle Iron Straightening Machines.
Air Compressors.

GIRDERS. BRIDGES. ROOFING.

DESIGNS AND ESTIMATES ON APPLICATION. E167a

DE BERGUE & CO., LTD., STRANGEWAYS IRONWORKS, MANCHESTER.

BURNHAM, WILLIAMS & CO., Philadelphia, Pa., U.S.A.

General Agents—SANDERS & CO., 110, Cannon Street, London, E.C.

BALDWIN LOCOMOTIVE WORKS.

LOCOMOTIVES

Broad and Narrow Gauge. Single Expansion and Compound.

Mine, Furnace & Industrial Locomotives. Electric Locomotives with Westinghouse Motors & Electric Trucks.

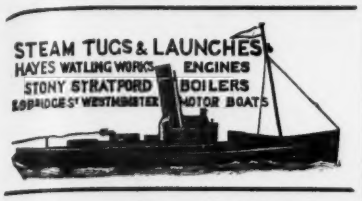
Cable Addresses—BALDWIN, PHILADELPHIA. SANDERS, LONDON. F747

Write for Catalogue illustrating

'REDMAN RAPID PLANERS'

Q971

PARKINSON LANE, HALIFAX.



ORR, WATT & Co., LTD.

Steel Structural Engineers.

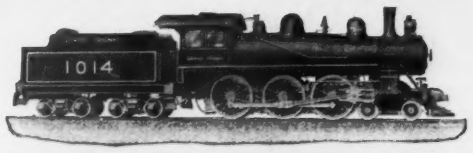
ROOF AND BRIDGE BUILDERS.

Hydraulic Pressed Steel Trough Flooring
For Road and Railway Bridges, Buildings, &c.

LANARKSHIRE BRIDGE WORKS, Carfin, MOTHERWELL, Scotland. S860

LOCOMOTIVES.

Steam. Electric.



Ten-Wheel Passenger Locomotive, built for the Grand Trunk Railway System.

THE LOCOMOTIVE & MACHINE CO. OF MONTREAL, LTD.

Y1018

Bank of Ottawa Building, Montreal, Canada.

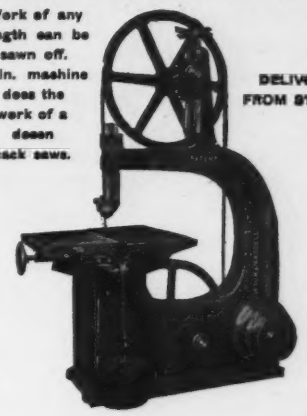
London Offices: 26, Victoria St., Westminster, S.W.

CLIFTON & WADDELL,

Metal Sawing Specialists,

JOHNSTONE, nr. GLASGOW.

Work of any length can be sawn off. 30in. machine does the work of a dozen hack saws.



DELIVERY FROM STOCK

SPECIALITY— Q869

Patent BAND SAWING MACHINES

Patent Circular Sawing Machines of all kinds for Cutting Iron and Steel

---

STEAM LAUNDRIES

(Institution and Public)

EQUIPPED WITH

MODERN MACHINERY

D. & J. TULLIS

LIMITED,

CLYDEBANK, N.B.

London Office and Showroom—
1, Southwark Bridge Buildings, S.E.
Indian Agents—Burn and Co. Ltd., Howrah.

Q211

GREAT LABOUR-SAVING TOOL.

Telegrams—Wilkinson, Engineers. Telephone—10 Y Keighley.

Duplex in Work Done
Single in Cost, Room & Wages.
Easily Manipulated.
Dozens Sold.

Independent Heads, can be run at different speeds, improved back and forward-facing motions, and variable feeds.

OTHER SPECIAL & GENERAL MODERN MACHINE TOOLS.

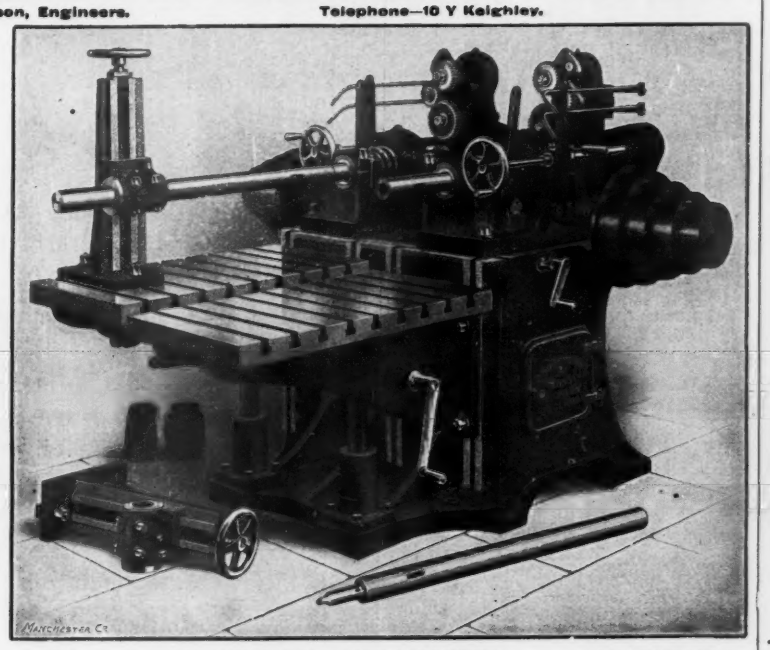
Very Large Stock

Special Low Prices and Particulars on Application.

C. WILKINSON & SONS

Bradford Road Tool Works,

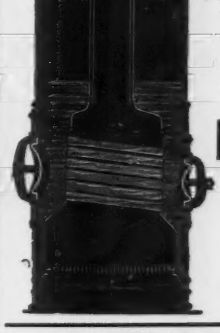
KEIGHLEY.



Q391 No. D78 DOUBLE BORING MACHINE. In Progress.

W. H. SPENCER & CO.,

Hitchin, Herts.



HOPWOOD

WATER-TUBE AND VERTICAL CROSS-TUBE

BOILERS

In Stock.

Y971

AIR RECEIVERS.

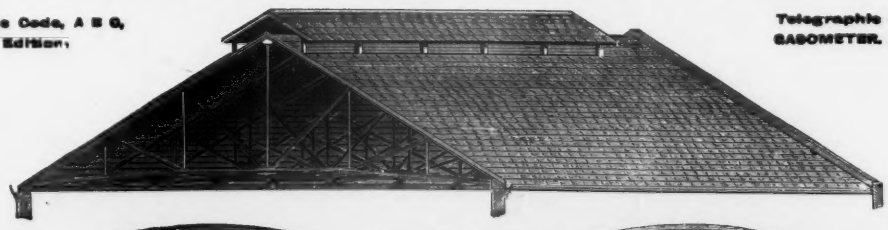
THE BARROWFIELD IRONWORKS,

GLASGOW. LIMITED,

Manufacturers of IRON & STEEL STRUCTURAL & OTHER WORK.

Telegraphic Code, A B C, 4th Edition.

Telegraphic Address—GASOMETER, GLASGOW.



Roofing,
Iron Buildings,
Loading Wharves
Promenade Piers

CASTINGS OF EVERY DESCRIPTION.

Water Towers.
All kinds of Cast Iron and Tanks.

STEEL RIVETTED PIPES WITH FLANGES, SOCKETS, OR COLLARS.

London Office: 6, Little Bush Lane, Cannon Street, E.C. Q187

SPECIFICATIONS AND ESTIMATES ON APPLICATION.

J. BUTLER & CO.,

Victoria Ironworks, HALIFAX.

High-class **MACHINE TOOL MAKERS.**

ESTABLISHED 1870. Q243

Telegraphic Address—BUTLER, HALIFAX, ENGLAND.

THOS. RYDER & SON,

Turner Bridge Works, BOLTON.

HIGH-SPEED LATHES

P HEAVY CUTS.

See Advertisement alternate weeks.

DAVIES & METCALFE,

MANCHESTER. LIMITED,

SPECIALITIES.

INJECTORS.

ALL CLASSES. Q404

Illustrated Advertisement last and next week.

ROBERT STEPHENSON & CO.

Locomotive Builders, DARLINGTON. Late Makers of

LOCOMOTIVES

of every Type and Gauge.

Telegrams—ROCKET, DARLINGTON. A B C, 4th edition Code used.

See Illustrated Advt. last and next week Q496

JAMES SPENCER & CO.,

Hollinwood, MANCHESTER.

Makers of **OVERHEAD TRAVELLERS**

and of ENGINEERS' MACHINE TOOLS. Q418

Lathes, Drilling & Screwing Machines in Stock.

THE STEEL COMPANY OF SCOTLAND, LTD.

SIEMENS PROCESS

EST'D 1872. "HALLSIDE"

23, ROYAL EXCHANGE SQUARE, GLASGOW.

WORKS: HALLSIDE, NEWTON, and BLOCHAIRN, GLASGOW.

OFFICES: 23, ROYAL EXCHANGE SQUARE, GLASGOW, and 9, MINCING LANE, LONDON.

CONTRACTORS TO BRITISH ADMIRALTY, WAR DEPARTMENT & FOREIGN & COLONIAL GOVERNMENTS

Manufacturers of

MILD STEEL Plates for Ships, Boiler and Bridge-building, Angles, Zed Bars, Tees, and all forms of Sectional Bars required for constructive purposes.
CASTINGS of all kinds and largest sizes for Ship Stems, Stern Posts, Anchors, Rudders, &c.
FORGINGS of every description.
AXLES of highest quality, to meet requirements of Home and Colonial Railways.
TYRES—Locomotive Carriage and Wagon, to all requirements.
SPECIAL STEEL of all kinds used for constructive purposes.

ESTABLISHED 1869.

LARGE PATTERN SHOPS.

LATEST APPLIANCES.

PATTERN MAKING

CHEAP, MEDIUM, or HIGH CLASS.

ACCURATE WORK.

DAVID BROWN & SONS (HUDD.) LTD.
C8196
East Parade Works,
HUDDERSFIELD.
Telegrams—PATTERNS Telephone—830.

GRAFTON & CO.,

CONTRACTORS TO H.M. GOVERNMENT.
ATLAS WORKS,
Telegrams—GRAFTON, BEDFORD.
BEDFORD.

Illustrated Descriptive Price List Free on Application.

The ONLY BRITISH STEAM CRANE used in the PARIS AND GLASGOW EXHIBITIONS C8186

TIME & MONEY-SAVING LUBRICANTS.

SNOWDRIFT (unequalled since 1884) for Crank Shafts, Crank Pins, Crossheads, Guide-bars, Line Shafting, &c.

SINOL, displacing Oil, for Cylinders of Steam and Gas Engines and Air Compressors.

Automatic, Mechanical, and other Lubricators.

Samples, Prices, and Full Particulars from the Manufacturers:—

SNOWDON, SONS & CO., LTD.,
MILLWALL, E.
Z209

Manchester: 7, Pall Mall. Birmingham: 20, Constitution Hill.

ADDRESSES:
Postal—Midland Ironworks, Loughborough.
Telegraphic—Coltmans, Loughborough.
Telephone—27 Loughborough (Nat.)

FOR

STEAM ENGINES

SIMPLE OR COMPOUND, UP TO 200 H.P.
ALSO BOILERS TO SUIT.

Apply—
H. COLTMAN & SONS,
MIDLAND IRONWORKS,
LOUGHBOROUGH.

Z110

ARTESIAN BORED TUBE WELL

At Bourne, Lincs., for the Town of SPALDING.

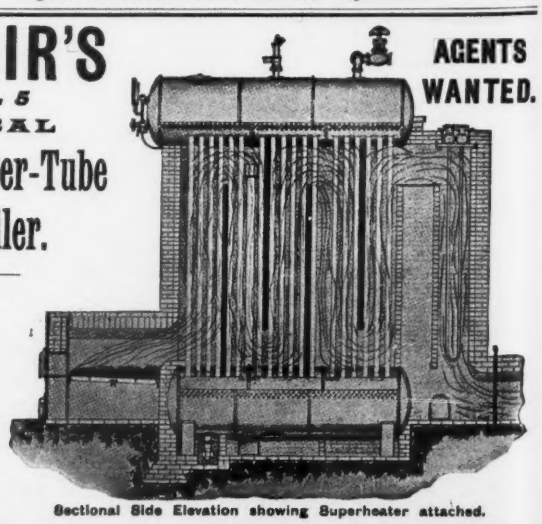
C. ISLER & CO., Bear Lane, Southwark, London
Artesian Well Engineers and Contractors to H.M. War Department. B3019

SINCLAIR'S

Patent No. 5
VERTICAL
Straight Water-Tube Steam Boiler.

AGENTS WANTED.

All parts circular in form and no bent tubes, therefore very strong. No hand-doors. Tubes easily removed from side. Cheap, simple, safe, self-cleaning, durable, and highly efficient. Made in sizes from 100 to 2000 h.p. in one unit.

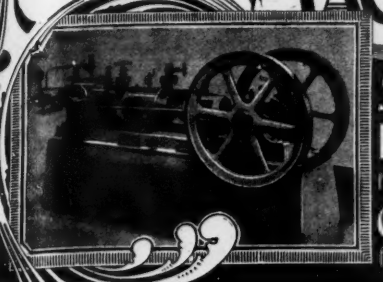


Sectional Side Elevation showing Superheater attached.

GEORGE SINCLAIR, Albion Boiler Works, LEITH, **SCOTLAND.**

AIR COMPRESSING MACHINERY

FOR ALL SERVICES.



SHONE PNEUMATIC EJECTORS for automatically raising SEWAGE, SLUDGE, WATER &c

COMPRESSED AIR LIFTS for raising water from BOREHOLES WELLS &c

FOR ESTIMATES & PARTICULARS APPLY TO HUGHES & LANCASTER, 16, Victoria Street, LONDON, S.W.

McDougall's Patent

GREASE EXTRACTOR

FROM EXHAUST STEAM.

For Condensing or Non-Condensing Steam Engines. The best method for preventing grease, &c., passing into the boilers. Intercepting and Collecting Chamber, combined with Hand or Automatic Drain.

McDougall's New Patent - - -

STEAM TRAPS

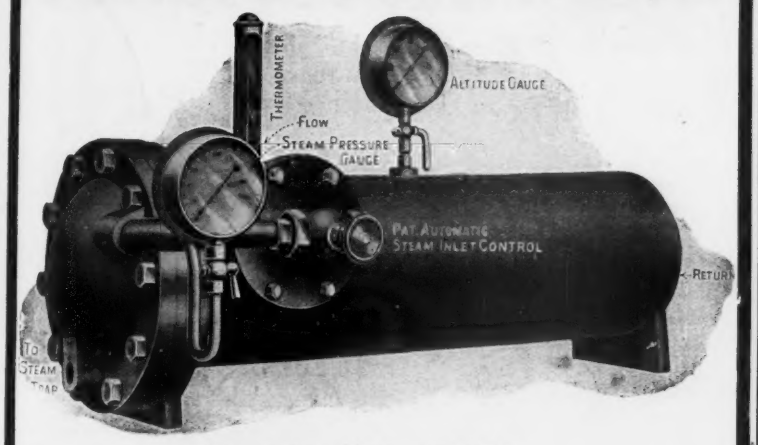
The very Latest. New Design for High Pressures and Superheated Steam.

Send for Particulars. Sole Makers— X1672

W. B. HAIGH & CO., LTD, PLANE ST., OLDHAM.

BERRYMAN PATENT

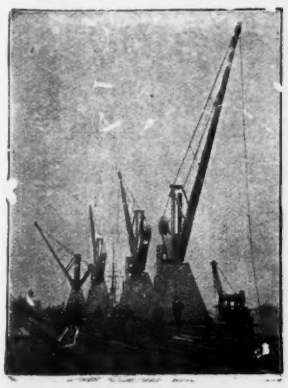
CALORIFIER.



OVER 2000 NOW WORKING.

Supplied to the Leading Hospitals, Asylums, Mansions, & Hotels in Great Britain

Sole Makers: JOSEPH WRIGHT & CO., TIPTON AND LONDON, STAFFS. 124, VICTORIA ST., S.W. S24



EAST FERRY ROAD ENGINEERING WORKS CO., Limited, MILLWALL, LONDON, E.

PATENT PNEUMATIC GRAIN ELEVATORS.

CRANES.

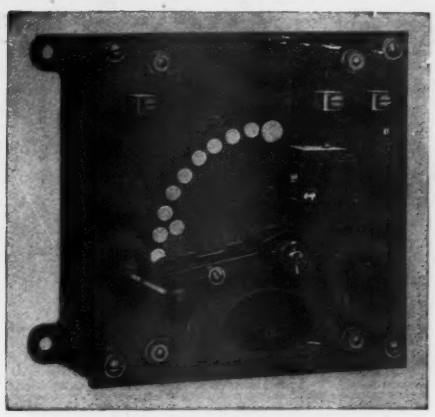
Duckham's Patent Suspended Crane Weighing Machines.

Sole Makers of PORTER'S PATENT SHIP'S DERRICK for heavy lifts.

Makers of RIGG'S PATENT COAL TIPPLERS.

STELLITE MOTOR STARTING GEAR.

Patented and Fully Protected



OPEN TYPE STARTER (with Button Contact).

Our Catalogue K 264 illustrates and describes a complete range of Motor Starters and Starter Panels—over 800 prices are quoted.

The construction throughout is of the highest grade, and the gear will be found to satisfy the present day requirements in every respect.

Our Patented Ironclad Combined Q.B. Lever Switch and Fuses are described in this Catalogue.

COMPETITIVE PRICES—ask for particulars.

× × × ×

Sole Manufacturers and Patentees—

The Electric & Ordnance Accessories Co., Ltd.,

STELLITE WORKS, ASTON, BIRMINGHAM

Branches and Agencies at

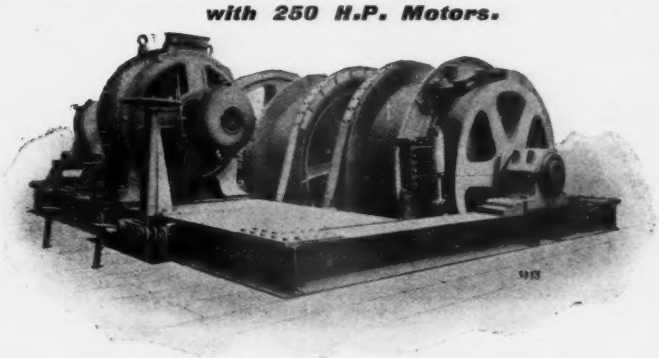
London, Glasgow, Newcastle-on-Tyne, Manchester, Hanley, &c. &c.

Contractors to—
H.M. Government.
Russian Government.
Japanese Government.
Leading Steamship & Railway Companies.
Municipal Electrical Depts. & Supply Companies.
Leading Engineering Co's, Electrical Contractors. &c. &c. Q592

HAULAGE MACHINERY

OF ALL DESCRIPTIONS.

Illustration shows one of three sets made by us with 250 H.P. Motors.



ERNEST SCOTT & MOUNTAIN, LTD.,

CLOSE WORKS, GATESHEAD.

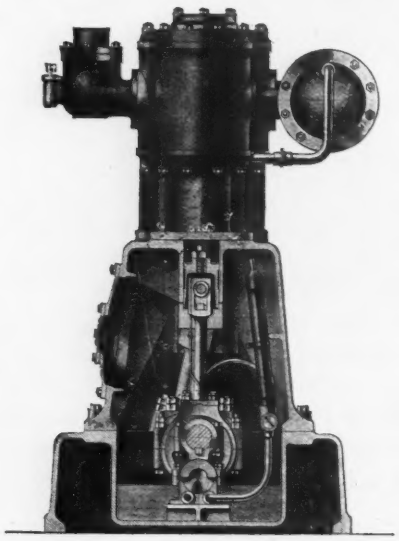
London Office:—49, Queen Victoria Street, E.C. B2095

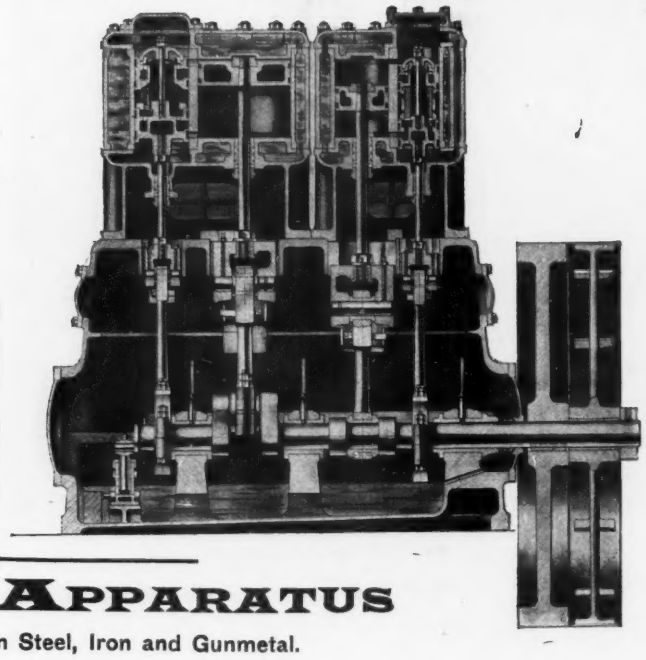
PATENT

HIGH-SPEED AIR COMPRESSOR.

Two-stage, Cross Compound Type, with Positively Operated Valves

Sizes from **300** *to* **1600** *cubic feet ot free air per min.*





SAND BLAST APPARATUS

For Cleaning Large or Small Castings in Steel, Iron and Gunmetal.

TILGHMAN'S PATENT SAND BLAST CO. LTD.,

BROADHEATH, near MANCHESTER.

12374

THE BEST STEAM EXCAVATOR

IN THE WORLD.

Employed by all the largest Contractors at Home and Abroad.

THE ONLY MACHINE THAT CAN SUCCESSFULLY DEAL WITH BOULDER CLAY AND ANY HARD MATERIAL

58

were used on the Manchester Ship Canal in all classes of Excavation.

They are in use in the Argentine, Brazil, Russia, India, China, Australia, South Africa, and in other countries.

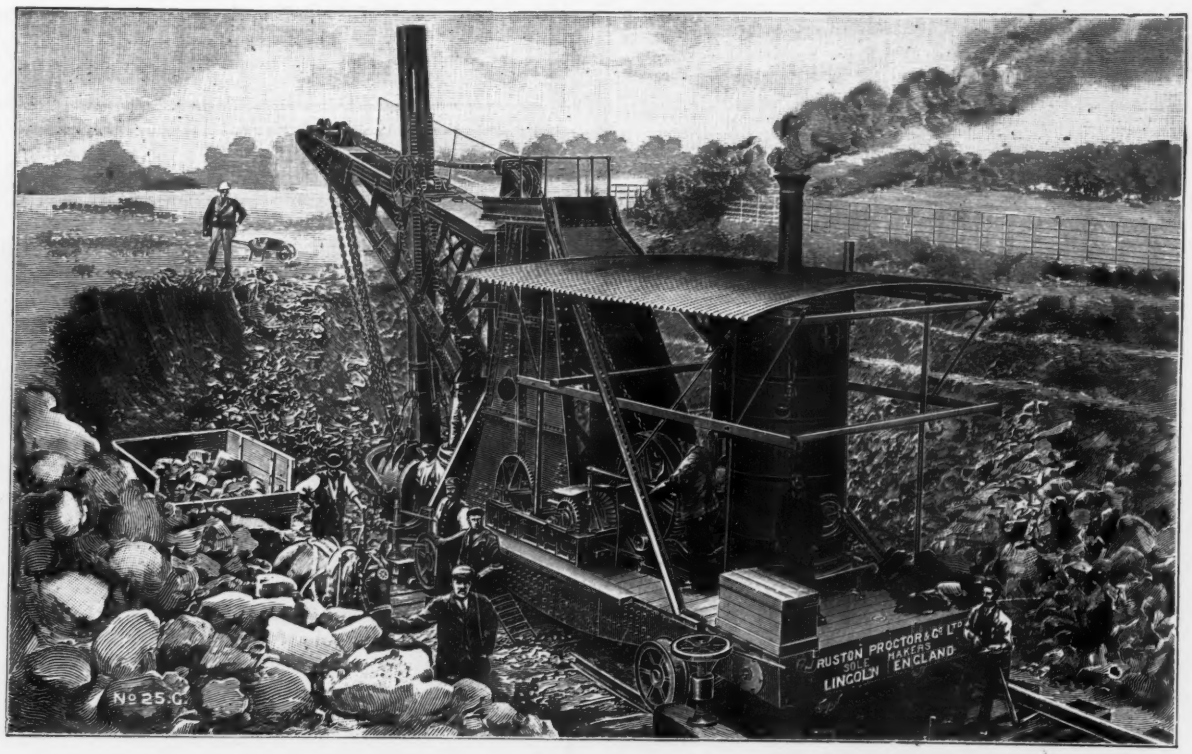
GREAT WESTERN RAILWAY.

Castle Cary to Langport Railway.

Contractors' Office,
Somerton, Somerset.
Feb 16th, 1906.

I have pleasure in testifying to the all-round excellence of your steam navvies during the construction of the above railway. Seven machines of your make have been constantly at work, mostly in cuttings consisting of alternate beds of rock and shale, and the work they have done in this material has been very satisfactory.

(Signed) A. S. Wills.



LONDON OFFICE:
46,
Queen Victoria St.
London, E.C.

In 10 hours will Fill into Wagons from 800 to 1,000 Cubic Yards of Hard Clay at a cost of 60s. to 70s. or about Three Farthings per Cubic Yard

Weight of Machine, 36 Tons.
Heaviest Piece, 110 cwt.

Over 280 in use.

012720

RUSTON, PROCTOR & CO. LIMITED, LINCOLN, ENGLAND.

SOLE MAKERS OF THE ONLY STEAM NAVVY.

THOMAS PIGGOTT & Co., LTD.

BIRMINGHAM.

London Water.—Staines Supply.—View of Pumping Station showing 6ft. 6in. Mains and Branch Pipes.

WELDED AND RIVETTED **STEEL PIPES.**

B5020

THE

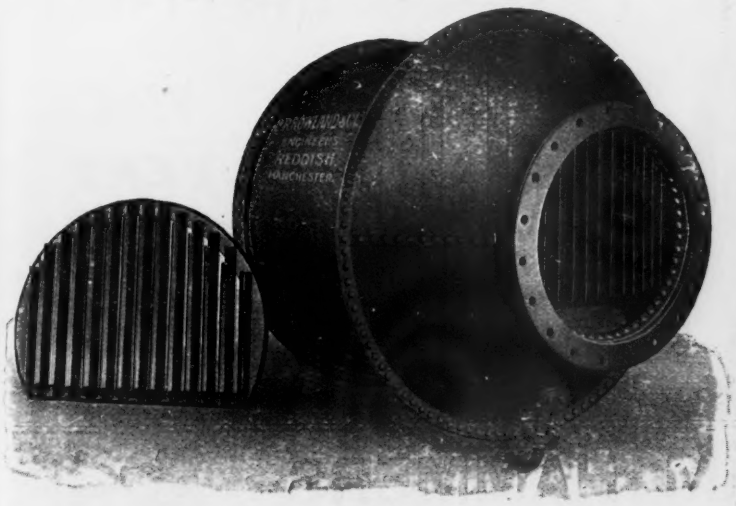
"CLIMAX" PATENT

OIL SEPARATOR

AND

OIL ECONOMISERS

FOR EXHAUST STEAM.



Separator Supplied for Treating 80,000 lbs. of Steam per hour.

OVER 500 PLANTS INSTALLED.

ABSOLUTELY PERFECT SEPARATION OBTAINED AND RECOVERY OF 70% TO 90% OF OIL.

Write for Illustrated Catalogue.

SOLE MANUFACTURERS,

B. R. ROWLAND & CO., Ltd.,

REDDISH near MANCHESTER.

Telephone No. 47 Heaton Moor. E1710 Tel. Address—Heroic, Reddish

Telephone 2110 AVENUE

Bullivant & Company, Ltd.

Inventors & manufacturers of Flexible Steel

wire ropes for Cranes, Lifts, Hoists Derricks &c.

Mining & Hauling Ropes

Makers of Specially designed BLOCKS PULLEYS CRAB-WINCHES AND ALL Appliances for working wire ropes.

AERIAL ROPEWAYS

designed & constructed on all systems. for the conveyance of goods of every description. Adaptable where no other form of transport can be used.

72 MARK LANE, LONDON EC Works MILLWALL, E

Fraser & Chalmers
Limited.

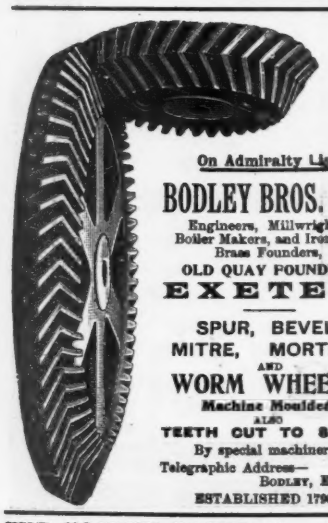
MINING MACHINERY.

WATER JACKET FURNACES
for Copper, Lead, and Nickel Ores, and Tin Slags.

REVERBERATORY FURNACES
for Roasting, Smelting, and Refining.

CONVERTORS
for Bessemerizing Copp nd Nickel Ores.

Head Office— Z262
3, LONDON WALL BUILDINGS,
LONDON, E.C.
Telegraphic Address: VANNER, LONDON



On Admiralty List.

BODLEY BROS. & CO
Engineers, Millwrights, Boiler Makers, and Iron and Brass Founders,
OLD QUAY FOUNDRY,
EXETER.

SPUR, BEVEL, MITRE, MORTICE, AND WORM WHEELS,
Machine Moulded.
ALSO
TEETH CUT TO SHAPE
By special machinery.
Telegraphic Address—
BODLEY, EXETER
ESTABLISHED 1790. L08

THE VACUUM BRAKE CO., Ltd.,
32, Queen Victoria Street,
LONDON, E.C
Telephone—5534 BANK. Telegrams—SOLUTION, LONDON
A B C and A 1 Codes used. Z92
For Large Advt. see Last and Next Week.

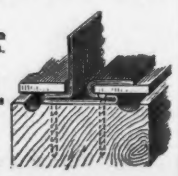
THE
CONSOLIDATED BRAKE and ENGINEERING COMPANY, LI ITED,
Spencer House, South Place, LONDON, E.C.
MANUFACTURERS OF THE
Standard Automatic Vacuum Brake
AND
Rapid Acting Service and Emergency Accelerators.
See Illustrated Advertisements last and next issue.
Telg.—"Vacuo, London." Telephone No.—3710 London Wall Z222

POP
SAFETY AND WATER RELIEF
Valves.

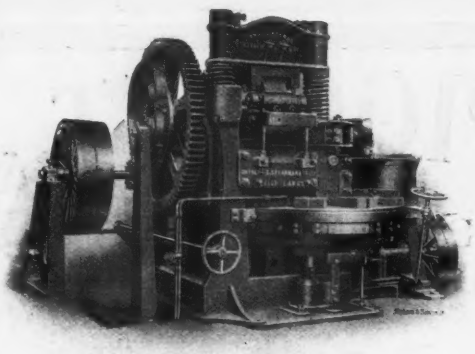
No. 16 as illustrated for
MARINE PURPOSES.
Special VALVES for MOTOR CARS
Send for our List 9A, post free. L622
ASHTON VALVE CO.
(HOSKELL, WAY & CO., LTD.)
124-5, Minories, LONDON, E.C.

SIMPLEX LEAD GLAZING

For Roofs, Skylight Horticultural Work
No Special Contract required.
NO ZINC, IRON OR PUTTY USED.
Any quantity supplied.
Millions of superficial feet in use on thousands of structures.



GROVER & CO., Ltd.
Engineers, &c.,
BRITANNIA WORKS,
Wharf Road, City Road,
LONDON, N.
Write for Illustrations, Testimonials and full Particulars (sent post free). X1167a



The Emperor Press.

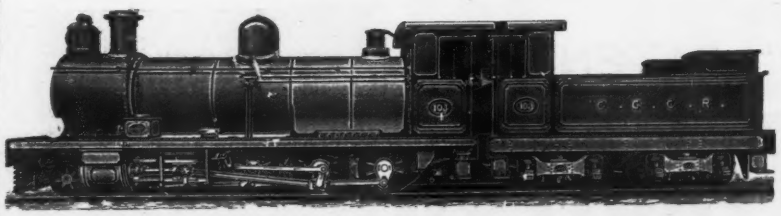
FOR
BRIQUETTING AND BRICK-MAKING
Plants installed for Briquetting Coal, Coke, Iron, and other ores.
MAKERS OF
ALL CLASSES OF BRICK-MAKING MACHINERY.
9 REPEAT ORDERS FOR EMPEROR PRESSES LAST YEAR.

STRENGTH.
SIMPLICITY.
EFFICIENCY.

SUTCLIFFE, SPEAKMAN & CO., Ltd.,
Engineers, LEIGH, LANCS.
Q619

JOHN OAKEY & SONS, LIMITED,
MANUFACTURERS OF
GENUINE EMERY, EMERY CLOTH, EMERY CORUNDUM CARNET & FLINT } TAPE
GLASS PAPER, BLACK LEAD.
FLINT AND CARNET PAPER. EMERY & CORUNDUM DISCS
Of CLOTH & PAPER, for all DISC GRINDING & POLISHING MACHINES.
N.B.—All Papers and Cloths are supplied in Rolls, Reams, Discs, Strips, and Sheets of almost any size and shape, to suit the special requirements of buyers. Prices quoted on receipt of particulars. H30
EMERY WHEELS.
WELLINGTON MILLS, WESTMINSTER BRIDGE ROAD, LONDON, S.E.

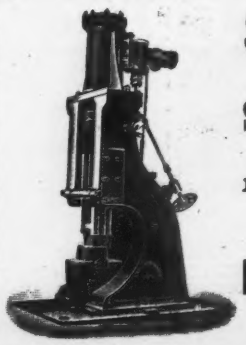
R. & W. HAWTHORN, LESLIE & CO., LTD.
Locomotives



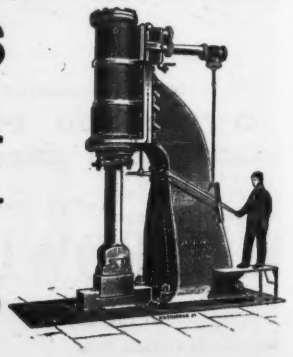
Marine Engineers and Shipbuilders.

Of every description for Home and Foreign Railways.
Tank Engines & Combined Cranes and Locomotives
Always in Stock and in Progress.
Collieries, Ironworks, Railway Depots, Branch Lines, Contractors, &c.
Tel. Ad.—LOCOMOTIVE, NEWCASTLE-ON-TYNE
ESTABLISHED 1817. G800
NEWCASTLE-ON-TYNE

HOWELL & CO., LTD. Brook Steel Works and Sheffield Tube Works, SHEFFIELD.
HIGH-SPEED TOOL STEEL. VITRITE BRAND. THE VERY BEST!!
SPECIAL STEELS FOR MOTOR CARS.
CHROME. NICKEL AND VANADIUM STEELS.



STEAM HAMMERS
FOR SMITHS' SHOPS AND FORGES.
SHIPBUILDERS' & BOILERMAKERS' MACHINE TOOLS.
Patent Bevelling Machines for Ships' Frames.
FORGE CRANES, HAND and STEAM. B11
Sugar Cane Mills. Water Wheels, &c. Hydraulic Presses.
DAVIS & PRIMROSE, JUNCTION ROAD,
LEITH, EDINBURGH.



SPECIAL ELECTRIC TRANSPORTER ROOF CRANES, BUILT FOR THE MERSEY DOCK AND HARBOUR BOARD, LIVERPOOL.
RADIUS—MAXIMUM 47ft., MINIMUM 3½ft.

SPECIAL FEATURES.

VERY RAPID DISCHARGING OF CARGO.
NO VALUABLE SPACE WASTED.
ECONOMICAL AND EFFECTIVE WORKING.

SPECIALISTS in
Plants for the Rapid and Economical Handling of all kinds of Ships' Cargoes, &c. &c.

APPLEBYS LTD.

An AMALGAMATION of JESSOP & APPLEBY BROS. (LEICESTER & LONDON), LTD., and THE GLASGOW ELECTRIC CRANE & HOIST CO., LTD., with which is incorporated

THE TEMPERLEY TRANSPORTER COMPANY.

WORKS: GLASGOW & LEICESTER. G1529

58, VICTORIA ST., LONDON, S.W.

PRIDMORE MUMFORD FARWELL

MOULDING MACHINES

J. W. JACKMAN & CO., LTD.,

LONDON: Caxton House, Westminster.
MANCHESTER: 347, Chester Road
GLASGOW: 60, St. Enoch Square O1507

HIGHEST GRADE

ENGINEERING & MECHANICAL COMPONENTS.

EVERY DESCRIPTION OF
PRESS-WORK EXTRUDING, SHAPING, MILLING, &c.
ANY Section in ANY Metal of
TUBES, RODS, STRIPS, SHEETS OR WIRES.
We can supply to Gauges any of your parts in Machine Sundries or Accessories. Z251

H. WATERSON & SON, 69, Albert Rd., Aston, BIRMINGHAM.

THE COIL CLUTCH CO., LTD., Phœnix Works, JOHNSTONE, SCOTLAND.

COIL CLUTCH REVERSING GEAR FITTED TO ROLLING MILL, 2000 horse-power.

Clutches FOR
Hauling
Winding
Pumping
Stamping
Grinding
Air Compressors
Rolling Mills
Motor Cars
Motor Launches
&c. &c.

CHARLES McNEIL, Specialist in Hydraulic Stampings & Forgings, Kinning Park Ironworks, GLASGOW

Stamped Steel Pistons up to 50in. Diameter.

WELDLESS LOCOMOTIVE DOMES up to 1½in. Thick.
Code, 5th Edition A B C.

Original Patentee and Maker of Embossed Manhole Doors.

AIR COMPRESSORS

VACUUM PUMPS.
For all purposes.
PORTABLE PLANTS.

LACY-HULBERT & CO., LTD.,
Pneumatic Engineers,
91, Victoria St., LONDON, S.W.
Telegrams—"Percussive," London. 'Phone—944 Victoria D89

GRAPHITE LUBRICANTS

Are splendid economisers when you get the right Graphite. DIXON'S supply the best Graphite Lubricants, put up in

RED LABEL TINS.

A1860

Machine-cut Gearing.
Rawhide Pinions.

Ad. Ahlers,
Sunderland.

Nat. Telephone—01553.
Telegrams—"Ahlers, Sunderland. Y825

JOHN H. WIDDOWSON

(16 Years Manager at Sir Joseph Whitworth & Co.'s),
BRITANNIA WORKS, Ordsall Lane, SALFORD, MANCHESTER
MANUFACTURER OF

STOCKS, DIES and TAPS,

IMPROVED TUBE PLATE TAPPING APPARATUS,
TAPS FOR "BELLEVILLE" BOILERS,
AND
EVERY DESCRIPTION OF SCREWING TACKLE, &c. X1538

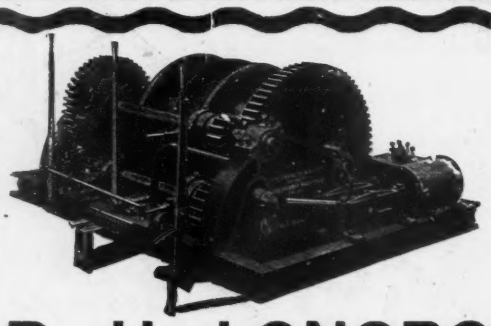
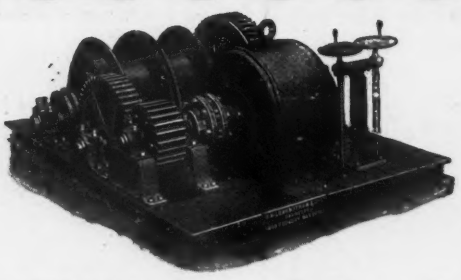
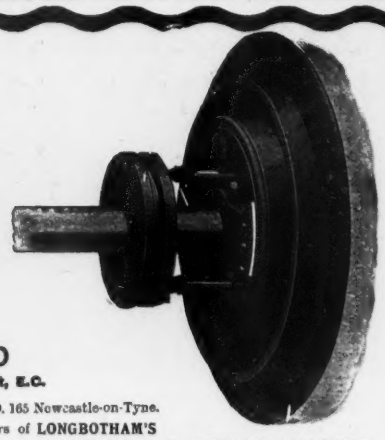
BOILER MOUNTINGS.

Complete Sets or Single Fittings and ***Renewable Valves.*** For High Pressures and Superheated Steam Services.

TO SECURE ECONOMY, USE THE BALDWIN PATENTS.

Send for Catalogue, post free. Z225

JAMES BALDWIN & CO.,
Engineers, DEVONSHIRE BRASS WORKS, ***KEIGHLEY.***

R. H. LONGBOTHAM & CO., LTD

Ings Foundry, WAKEFIELD. London Office: 185, Queen Victoria Street, E.C.
Newcastle-on-Tyne Office: 3, St. Nicholas Buildings.
Telegrams—"Engineer, Wakefield"; "Selftain, London." Telephones—Nat.: No. 44 Wakefield; P.O. No. 2294 Central, London; P.O. 165 Newcastle-on-Tyne.

Makers of Improved Self-contained WINDING, HAULING, or CAPSTAN ENGINES, on Steel Girder Frames.
Arranged to combine Strength with Rigidity. All parts Easy of Access and Detachable, thus rendering them Light and Inexpensive for Transport.

ELEVATORS, CONVEYORS, CAGES, SCREENS, COAL FACE CONVEYORS, TIPPLERS.

Sole Makers of LONGBOTHAM'S
Improved Patent FRICTION CLUTCH
which gradually takes up load and releases same without shock when running at any speed up to 1000 r.p.m.
ELECTRICAL HAULAGE GEAR
fitted with Flexible Coupling and Improved Patent Friction Clutch on Steel Girder Frame. 8p) ONI

LATEST IMPROVEMENT IN BOILER SETTING.

THE ADJUSTABLE.

Boiler laid bare to daylight, inspected and re-covered in a few hours without dismantling brickwork.—Economy of fuel. ONI 4

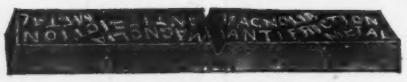
THE ADJUSTABLE COVER & BOILER BLOCK CO., Ld., 64, VICTORIA STREET, WESTMINSTER, S.W.

MAGNOLIA METAL.

"Flower" Brand.

BEST ANTI-FRICTION METAL for all Machinery Bearings.
Specify Magnolia Metal "Flower" Brand to prevent imposition. ONI 5

THE NAME AND TRADE MARK APPEAR ON EACH BOX AND INGOT OF GENUINE METAL.



BERLIN—Friedrich Strasse, 71. PARIS—50, Rue Taitbout BELGIUM—36, Rue de l'Universite, Liege.
Telephone—5925 Bank. Telegrams—Magnoliter, London

"Flower" Brand.

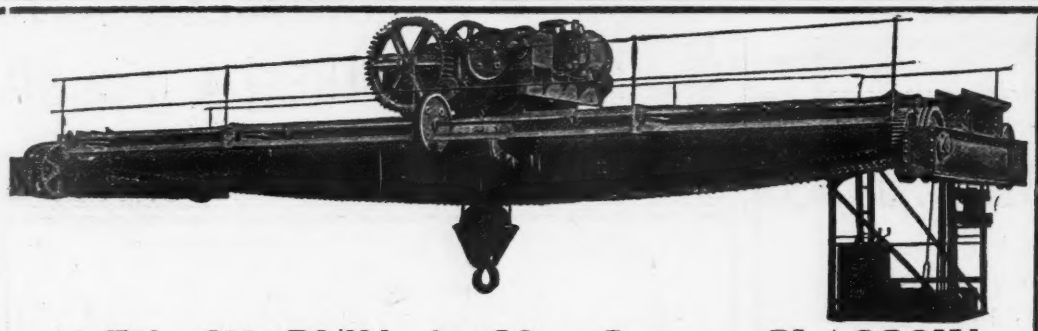
MAGNOLIA ANTIFRICTION METAL CO. OF GREAT BRITAIN, LTD., 49, Queen Victoria St., LONDON, E.C.

CARBROOK STEEL WORKS, SHEFFIELD.

DIE BLOCKS & DIE STEEL BARS

(For Hot and Cold Stamping). Y998

ROLLED BARS. FORGINGS.



ALEX. CHAPLIN & CO., Govan, GLASGOW.

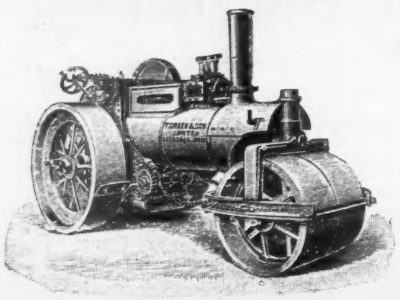
CRANES

Electric, Steam, Hydraulic, Hand
OF ALL TYPES.

WINDING & HAULING ENGINES.

SHEERLEGS, SLIPWAYS. M1

THOMAS GREEN & SON, LIMITED.



IMPROVED PATENT

STEAM ROAD ROLLERS.

WITH OR WITHOUT PATENT ROAD SCARIFIER.
Also Makers of VERTICAL, CORNISH, AND LOCOMOTIVE BOILERS.
ESTIMATES SUPPL'ED FOR ROLLER REPAIRS.

Prices and Specifications on application— I 28

THOMAS GREEN & SON, LIMITED,
Smithfield Ironworks, LEEDS, and New Surrey Works, Southwark Street, LONDON, S.E.

INDEX TO ADVERTISEMENTS.

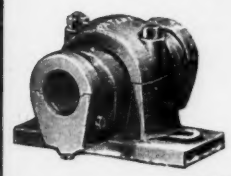
Advertisements not appearing this week, but included in the "Subject Matter Index," will be found by reference to the preceding or following issues, with the exception of those appearing monthly.

	PAGE
Abbott and Co. Ld	28
Adams, George	65
Adjustable Boiler Block Co	52
Adlam, G., and Sons	4
Ahlers, Ad.	61
Akrill, C., and Co., Ld	10
Allan, Whyte and Co	11
Allen, W. H., and Co., Ld	31
Alley and Macleilan, Ld	28
Applebys Ld	61
Armstrong, Stevens and Son	52
Arrol, Sir W., and Co., Ld	42
Asbestos Co., Ld., United	34
Ash, J., and Son	65
Ashton Valve Co	60
Asquith, W., Ld	2
Atlas Metal & Alloys, Ld	42
Auld, D., and Sons	3
Au o-Controller & Switch Co	6
Avonside Engine Co	2
Babcock and Wilcox Ld	47
Bagnall, W. G., Ld	28
Bagshaw, J., and Sons	66
Bailey, W. H., & Co., Ld	5
Bain, W., and Co	14
Baker, J., & Co. (Rotherham)	18
Baker's Pat. Appliances Co.	41
Balcke and Co	45
Baldwin, J., and Co	61
Barns, W., and Son	42
Barrowfield Ironworks, Ld.	55
Barry, Henry and Co	5
Batchelor, R. D.	6
Baxter, W. H., Ld	66
Beardmore, W., and Co	44
Beeley, T., and Son, Ld	3
Bennie, J., and Sons	40
Bennis, E., and Co., Ld	26
Bertrams Ld	2
Best Belting Co	6
Blackstone and Co., Ld	40
Blair, Campbell and McLean	43
Blake, Barclay and Co	4
Blake Boiler, Wagon, &c., Co	3
Boby, R.	66
Bonney Bros. and Co	60
Booth, Jos., and Brothers	54
Borsig, A.	52
Boving, J. O.	2
Boyle, Robt., and Son	35
Braby, F., and Co	8
Brackett, F. W., and Co	25
Bradley and Craven, Ld	32
Bradley, T. and W., Ld	35
Brami ey Engineer'g Co., Ld	66
Brazil, Straker and Co., Ld	
Brearley, Fairbank, Ld	3
Bridge, D., and Co	2
Brightside Foundry & Eng. Co	41
Britannia Co	64
British Bronze and Silvo Metal Co., Ld	16
Broadbent, T., and Sons	22
Brooks, J. B., and Co	7
Brown Bayley's Steel Works	64
Brown, D., and Sons	56
Brownlie and Murray Ld	41
Bruce and Still, Ld	42
Buckton, J., and Co., Ld	69
Bullivant and Co. Ld	59
Bull's Metal & Melleid Co., Ld	35
Burnham William and Co	55
Butler, J., and Co	65
Butte field, W. F.	3
Butterley Company, Ld	2
Caird and Rayner	36
Cameron, J.	61
Cammell Laird and Co., Ld	15
Campbell Gas Engine Co	17
Campbells and Hunter, Ld.	6
Carborundum Co	33
Carbrook Steel Works	62
Carrick and Weddle	45
Carver, C. F., Ld	33
Chaplin, A., and Co	62
Chatwin, T.	4
Clarkson's	66
Clay Cross Co	28
Cleveland Bridge & Eng. Co	41
Clifton and Waddell	55
Climax Patents, Ld	20
Clyde Structural Iron Co., Ld	43
Cochran and Co., Annan, Ld	55
Cone Clutch Co., Ld	61
Cole, Marchent and Morley	64
Coles, H. A., and Co	41
Coles, H. J.	53
Coltman, H., and Sons	56
Consolidated Brake & Eng. Co	60
Contraflo Condenser Co., Ld	34
Conveyor and Elevator Co	66
Cook and Hammond	65
Cooper, G., and Sons, Ld	3
Cowans, Sheldon and Co., Ld	48
Craven Brothers, Ld	35
Cravens Limited	2
Craig, A. F., and Co., Ld	42
Crompton, Thomas	35
Crosier, Stephens & Co.	33
Crossley Brothers, Ld	21
Cruse Superheatar Co	54
Cundall Sons and Co., Ld.	49
Dale, William	4
Daniell, Ld., S. A.	4
Daniels, T. H. and J., Ld	3
Davey, Paxman and Co., Ld	50
Davie and Horne	35
Davies and Metcalfe, Ld	56
Davis and Primrose	60
Davy Bros., Ld.	54
De Bergue and Co	54
Delta Metal Co	35
Denison, S., and Son, Ld	2
Dermatine Co, Ld	2
Dick, Kerr and Co	34
Dixon Crucible Co	61
D P. Battery Co, Ld	37
Drum Engineering Co	
Drummond Bros	2
Drysdale and Co	48
Dunkerley, C. C., and Co	5
Durvite Limited	66
East Ferry-road Engin'ng Co	57
Easton and Bessemer, Ld	6
Edmeston, A., and Sons	53
Edward's Air Pump Synd	65
Electric & Ordnance Accessories Co, Ld	57
Elliot, G., and Co. Ld	7
Entwistle and Gass, Ld	54
Escher, Wyss and Co., Ld	2
Evans, J., and Sons	47
Farmer, L., and Sons	66
Farnley Iron Co	2
Fawcett, Preston and Co., Ld	41
Fielding and Platt, Ld.	2-18
Findlay, Alex., and Co., Ld	43
Firth, T., and Sons, Ld	11
Fleming and Ferguson	7
Fraser and Chalmers, Ld	60
Fuller, Horsey, Sons & Cassell	46
Gandy Belt Manufturing Co	35
Gardner, L., and Sons	42
Garrett, R. and Sons, Ld	5
Gilbert Little Co., Ltd.	6
Gilkes, G., and Co	35
Gimson and Co., Ld	42 65
Glasgow Iron & Steel Co, Ld	63
Glasgow Railway Eng. Co	2
Glasgow Steel Roofing Co	54
Globe Gas Engine Co., Ld	54
Globe Pneumatic Eng. Co	51
Glover and Hobson, Ld	4
Glover, M., and Co	4
Goodwin, Barsby and Co	35
Grafton and Co	56
Grantham Boiler & Crank Co	8
Grant, Ritchie and Co., Ld.	6
Green, T., and Son, Ld	63
Grice, Grice and Son	48
Griffin, C., and Co	64
Griffith, W., and Sons	2
Grover and Co	60
Guest, Keen & Nettlefolds	46
Haigh, W. B., and Co., Ld	57
Haiden, J., and Co, Ld	48
Hall, B. J., and Co, Ld	4
Hall, J. and E., Ld	35
Hall, J. P., and Co., Oldham	54
Hall, J. P., & Sons, Ld., Peter	25
Hands, J., and Sons	4
Handyside and Co., Ld	16
Hardy and Padmore, Ld	25
Hardy Patent Pick Co., Ltd.	53 66
Harpers Limited	66
Harris and Mills	35
Harrison and Camm, Ld	2
Hart, A., and Co	43
Hartley and Co	4
Hartnell, W., and Co., Ld	41
Haslam Foundry & Eng. Co., Ld	38
Haste Pump Co., Ld	8
Hawthorn, Leslie & Co.	60 65
Hayes, Edward	55
Hayward-Tyler and Co	27
Head, Wrightson & Co., Ld	48
Heap, J., and Co., Ld	26
Heenan and Froude	4
Henderson, J. M., and Co	63
Hendry, James	40
Henry, J., Ld	14
Herbert, A., Ld	2
Heywood, S. H., and Co., Ld	4
Higginbottom and Mannock	41
Hill, G., and Co	3
Hill, J. and P.	2
Hodges and Co	41
Holden and Brooke, Ld	7-27
Holt and Willetts	27
Hooker, F.	2
Hopkinson, J., and Co., Ld	2
Horseley Co. Ld	17
Howard Engineering Co	23
Howell and Co., Sheffield	60
Hudson, R.	30
Hudswell, Clarke and Co.	14
Hughes and Lancaster	57
Hulburd Engineering Co	8
Hulse and Co., Ld	35
Hunslet Engine Co	10
Ince Forge	65
India-rubber Mfg. Co., Ld	64
Irwin, R. C.	4
Isca Foundry and Eng. Co.	65
Isler, C., and Co	65
Jackman, J. W., and Co., Ld	61
Jensen and Son	36
Jessop & Appleby Bros., Ld	61
Johnson and Phillips	66
Jones & Lamson Machine Co	6-21
Jones, George, Ld	37
Kaye, J., and Sons	53
Kenyon, W., and Sons	8
Kerr, Stuart and Co	2-15
Kirk, Price and Co.	1-65
Kirlew Bros., Ld	3
Klein Engineering Co, Ld	3
Klinger, R., and Co	19
Koppel, A.	37
Korting Brothers, Ld	3
Lacr-Hulbert and Co., Ld.	61
Lanarkshire Bolt & Rivet Co	3
Lancaster and Tonge, Ld	7
Lancaster, C.	2
Lane, H.	66
Lassen and Hjort	3
Laurence, Scott and Co., Ld	50
Lawrie, W. S., Ld	66
Ledward and Beckett	35
Lee and Hunt	65
Leeds Forge Co., Ld	11-34
Lees, T. and R.	3
Lewis and Tylor, Ld.	6
Lidgerwood Mfg. Co	4
Lion Spring Co.	42
Liverpool Eng. and Cond'r Co	42
Llewellin's Machine Co	35
Lockwood and Carlisle	43
Loco. & Mach. Co., Montreal	55
Loewe, L., and Co., Ld.	37
Lodge Bros. and Co	3
Longbotham, R. H., & Co	62
Lotz, M., and Co	3
Lowcock, A., Ld	40
Lake and Spencer, Ld	52
Lunken Valve Co	4
Lysaght, John, Ld.	17
Macdies, Ld	54
Macilellan, P. and W.	2
Magnolia Metal Co., Ld	62
Mann's Patent Wagon Co	35
Mansfield, E., and Sons	8
Marple and Gillott	54
Marshall, Fleming & Co	6
Mason Bros.	32
Measures Brothers, Ld.	52
Mercer, E.	6
Merryweather and Sons, Ld	24
Midland Rly Car & Wagon Co	2
Miller & Co., Ld	4
Mirfield Engineering Co., Ld	25
Mirrlees Watson Co., Ld	40
M'Neil, C., Jun	61
Moncrieff, J.	35
Morris and West	35
Moseley, D., and Sons, Ld	34
Motherwell Bridge Co., Ld	25
Muir, W., and Co	32
Mumford, A. G.	3 49
Musgrave and Co., Ld	37
Musker, G. and A., Ld	29
Nasmyth, Wilson and Co., Ld	15
National Gas Engine Co., Ld	38
Neil, James	42
Neville Machine Tool Co	33
New Conveyor Co., Ld	66
Newall Engin'ring Co., Ld.	6
Newell, E., and Co., Ld	65
Newton, Chambers & Co., Ld	9
Noble and Lund	53
Normandy's Fresh Water Co	37
North British Loco. Co., Ld	39
Oakey, J., and Sons	66
Orr, Watt and Co., Ld	53
Parker, Thomas, Ld	12
Parkinson, J., and Son	52
Parsons, C. A., and Co	3
Pearn, F., and Co	21
Peckett and Sons	44
Pfeil and Co	45
Phillips, J., and Co	6
Phœnix Foundry Co., Ld	49
Pickering, R. Y., & Co., Ld	2
Piggott, T., & Co., Birmingham	59
Pilkington Bros., Ld	32
Platt, Samuel	63
Player, W. and J.	4
Plenty and Son, Ld	9
Pollock, Macnab & Highgate	4
Pott, Cassels and Williamson	2
Pratt, F., and Co., Ld	41
Premier Gas Engine Co., Ld	47
Price, J.	65
Pulsometer Engineering Co	34
Radford, Sons and Square	66
Ransome, A., and Co., Ld	46
Reader, E., and Sons, Ld	33
Redfern, G. F., and Co	35
Redman, C., and Sons	55
Reinecker, J. E.	45
Renshaw, W. R., and Co., Ld	2
Rhodes, J., and Sons, Ld	27
Richards and Thompson, Ld	3
Richards, R., and Co	2
Robey and Co	32
Robinson, T., and Son, Ld	32
Robson, G., and Co	35
Rodger, A., and Co.	39
Roots, J. D., and Co	35
Ross and Duncan	45
Rosser and Russell	65
Rowell, D., and Co	6
Rowland, B. R., and Co., Ld	59
Royles Limited	35-45
Russell, George, and Co	33
Russell, James, and Sons, Ld	33
Ruston, Proctor and Co	56
Ryder, T., and Son	55
Samuelson and Co., Ld	43
Sandycroft Foundry Co., Ld	14
Scharan, Harker and Co	66
Schinkardt and Schutte	19
Scott and Mountain, E., Ld	57
Selig, Sonnenthal and Co	23
Shanks, T., and Co.	33
Sheppee Motor Co	16
Shewell, J., and Co.	2
Shore, T., and Sons	6
Siebe, Gorman and Co	7
Sinclair, G.	56
Smith, G. B., and Co	16
Smith, T., and Co	4
Smulders, A. F.	51
Snowdon, Sons and Co., Ld	56
Spencer, J., and Co	55
Spencer, J., and Sons	65
Spencer, J., Ld	66
Spencer, W. H. and Co	55
Stableford and Co., Ld.	6
Stanley, W. F.	45
Steel Company of Scotland	55
Stephenson, R., and Co., Ld	56
Sterne, L., and Co	35
Stewarts and Lloyds, Ld	38
Stirk, J., and Sons	16
Stirling Boiler Co., Ld	8
Storey, I., and Sons, Ld	35
Stothert and Pitt	44
Summerscales, W., and Sons	32
Sutcliffe, Speakman and Co	60
Swain, John, and Son, Ld	33
Tandem Smelting Synd., Ld	45
Tangres Limited	9
Taylor and Challen, Ld	19
Taylor and Hubbard	37
Tempered Spring Co., Ld	33
Tennent, R. B., Ld	2
Thermit, Ld	19
Thompson & Southwick, Ld	2
Thompson, Jonas	16
Thornton and Crebbin, Ld	58
Thornycroft, J. I., and Co	10
Thorp, J. B.	66
Tilghman's Sand Blast Co.,	58
Tinker, Shenton and Co.	44
Tomey, J., and Sons, Ld	28
Trier Brothers	25
Trussed Concrete Steel Co	35
Tullis, D. and J., Ld	53
Turnbull, A., and Co., Ld	45
Turner, E. E. and F.	4-52
Turner, G. K., Ld	2
United Asbestos Co., Ld	34
U K Lighting Trust, Ld	33
U.K. Metallic Packing Synd	41
Urquhart, Lindsay & Co., Ld	39
Vacuer, H. F.	3
Vacuum Brake Co., Ld	60
Vaughan and Son, London	35
Vickers, Sons and Maxim	5
Vulcan Boiler Insurance Co	41
Wadkin and Co	3
Wakefield, C. C., and Co	3
Walker, J., and Co	69
Wallis Valve Mfg. Co	36
Ward, H. W.	25
Ward, T. W., Ld	2
Waterson, H., and Son	61
Watkins, S., Son and Groves	35
Webb and Son	42
Weir G. and J., Ld	64
Weldless Steel Tube Co	2
Wellman Seaver-Morgan Co	15
Wells, A. C., and Co	25
Wheeler Co. Ser & Eng. Co	8
White, T., and Sons	43
Widdowson, J. H.	21
Wigglesworth, F., & Co., Ld	37
Wilcinson, G., and Sons	55
William's, Alfred, and Co	43
Williamson	58
Willcox, W. H., and Co., Ld	7
Wilson, Alex.	2
Wilson, J. H., and Co., Ld.	23
Winter, F.	6
Wood and Newland	61
Wootton Bros.	35
Worthington Pump Co	4
Wright, Joseph, and Co	57
Yarrow and Co.	63

The Index to the Subject Matter of Advertisements appears on the following Right-hand Page.

SAMUEL PLATT, LD.

WEDNESBURY.



SHAFTING

BEARINGS

PULLEYS.

PLANTS FOR MANUFACTURING

BOLTS & NUTS, TUBES & FITTINGS, BRIGHT-DRAWN & REELED BARS, DROP-FORGINGS.

Agent fur Deutschland: TH. BOOK, Elberfeld. Agent pour la France: FERNAND PERDRIZET, 32, Boulevard Magenta, Paris. Z17

GEORGE ADAMS 21/3, Short's Gardens Long Acre, London, W.C.

CUT GEARS

of all descriptions, in all materials; also fine and accurate machine work of every kind. Teeth of all bevel gears planed to accurate templates, and any one of a pair accurately matched. Gear Boxes made in quantity, also Car Parts, Worms, Sectors, Shafts, &c. Exact Repetition Work.

YOUR ENQUIRIES SOLICITED.

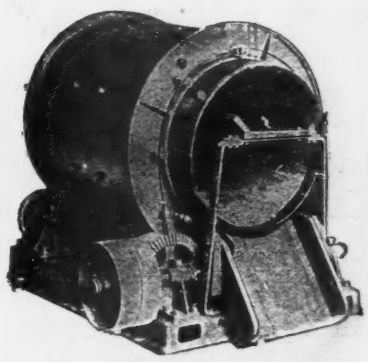
ESTIMATES BY RETURN. Repairs to above quickly and accurately carried out.

ALL WORK EXECUTED ON THE PREMISES. D49

MAGNETIC SEPARATOR.

For Separating Iron and Steel from any other Material.

THE MOST PERFECT MACHINE ON THE MARKET.



AS SUPPLIED TO THE ADMIRALTY.

PRICES ON APPLICATION.

Sole Makers:—

The HARDY PATENT PICK CO., Ltd.

SHEFFIELD, ENGLAND. (Spl)51

CRANES ALL TYPES

JOHN M. HENDERSON & CO.

ABERDEEN, Scotland.

Y440

AERIAL CABLEWAYS & ROPEWAYS.

THE GLASGOW IRON & STEEL CO., LTD., WISHAW, SCOTLAND.

Manufacturers of SIEMENS' ACID STEEL

SHIP & BOILER PLATES

Also BILLETS of dead soft quality, SLABS, BRIDGE PLATES, ANGLES, BULBS, CHANNELS, ROUNDS, SQUARES, TEES, ZEDS, &c.

Telegraphic Address "INGOT, WISHAW."

FOR MARINE TURBINE INSTALLATIONS.

Complete
Feed Pump,
Feedheating,
High Vacuum
Air Pump
and Condensing
Plants

designed, arranged and furnished
for all classes of vessels
on the latest lines.

Spl) 1870

G. & J. WEIR, LTD. CATHCART, GLASGOW

SILVERTOWN

Dynamos, Motors, Cables, Wires,
Instruments, Batteries, Carbons.

The India Rubber, Gutta Percha, & Telegraph Works Co., Ltd.,

Head Offices: 106, Cannon Street, London, E.C. **Works:** Silvertown, London, E.

Telegrams: Offices—"Silvergray, London." Works—"Graysilver, London." (Spl) 1867

Branches: Belfast, Birmingham, Bradford, Bristol, Cardiff, Dublin, Glasgow, Liverpool, Manchester, Newcastle-on-Tyne, Portsmouth, Sheffield.

COLE, MARCHENT & MORLEY, LTD.

Corliss and Piston-drop-valve Engines, Mill Work, Independent Condensing Plants, &c.
Telegrams—COLE, BRADFORD Telephone 690.

Prospect Foundry, BRADFORD. Send for our Catalogues Spl) 1868

Brown Bayley's Steel Works Ld., Sheffield

Telegraphic Addresses—BAYLEY, SHEFFIELD; BALI, LONDON.

Manufacturers of STEEL by the "SIEMENS" & "BESSEMER" PROCESSES.

MAKERS OF
TYRES, AXLES, & SPRINGS for Railway Locomotives, Railway Carriages & Wagons, and for Tramway Engines & Cars

SPECIAL GUARANTEED SPRING STEEL, for Railway Locomotive Springs, Railway Carriage and Wagon Springs, and for Lurry, Dray, and Cart Springs.

STEEL FORGINGS.

PLANISHED STEEL BARS for Shafting for Engineers, Machinists, and Agricultural Implement Makers. ***Special Steel Blooms and Slabs.***

London Office: SUFFOLK HOUSE, 5, LAURENCE POUNTNEY HILL, E.C.

Australian Agents—W. and A. McARTHUR, Ltd., 16, Macquarie Place, SYDNEY. Spl) 1858

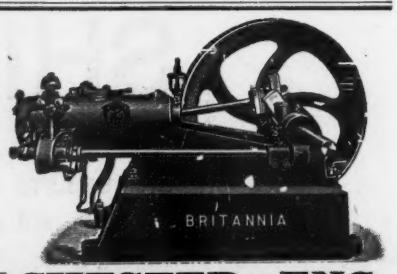
"BRITANNIA"

SAFETY AUTOMATIC
OIL ENGINE

This engine is quite different in design to any other manufactured, and is covered by two valuable patents. We make twelve distinct claims, and will be pleased to send you full particulars with copies of recent testimonials.

Will use any kind of CRUDE or REFINED Petroleum without alteration or constant cleaning

AGENTS WANTED.
AT HOME AND ABROAD.
WRITE FOR TERMS. D50



THE BRITANNIA ENGINEERING CO., LTD., COLCHESTER, ENG.

INDEX TO SUBJECT MATTER OF ADVERTISEMENTS.

The Numerical Index appears on the right-hand page preceding this page.

Agricultural Machinery
Fowler, J., and Co., Ld
Garrett and Sons, Ld
Ransomes, Sims and Jefferies
Ruston, Proctor and Co., Ld
Turner, E. R. and F., Ld

Air Compressors:
Alley and Macleilan, Ld
Arrol, Sir W., and Co., Ld
Brit. Westinghouse Electric Co
Brackett, F. W., and Co
Brotherhood, Peter
Consolidated Tool Co., Ld
Davey, Paxman and Co., Ld
Daw, A. & Z.
Hughes and Lancaster
Reavell and Co., Ld
Schram, Harker and Co
Siebe, Gorman and Co
Tilghman's Sand Blast Co., Ld
Walker Brothers, Wigan
White, T., and Son
Whiteley, S. S.
Worthington Pump Co., Ld

Air Pumps:
Bailey, W. H., and Co., Ld
Caird and Rayner
Carrick and Wardale
Edwards Air Pump Synd., Ld
Storey, I., and Sons, Ld

Anvils:
Wright, P., and Sons

Arc Lamps
Crompton and Co., Ld
Electric Ordinance and Accessories Co., Ld
Veritys Limited

Armour Plates:
Brown, J., and Co., Ld
Firth, T., and Sons, Ld

Artesian Well Engineers:
Batchelor, R. D.
Henderson, J., and Son Ld
Isler, C., and Co
Le Grand and Sutcliff
Richards, R., and Co
Williams Alfred, and Co

Asbestos Manufacturers:
Asbestos Co., Bell's, Ld
Asbestos Co., United, Ld

Ash Ejectors:
Trewent, F J.

Auctioneers and Valuers:
Farmer, L., and Sons
Fuller, Horsey, Sons & Cassell
Kirk, Price and Co
Radford, Son and Squire
Wood and Newland

Batteries:
D.P. Battery Co., Ld

Bearings:
Empire Roller Bearings Co., Ld
Fleming, Birkby & Goodall, Ld
Loewe, L., and Co., Ld
Main, G., and Co

Belting:
Best Belting Co., Ld
Cole, H. A., and Co
Gandy's Limited
Gehrckens, C. O.
Hendry, James
Lewis and Tylor, Ld
Reddaway, F., and Co., Ld
"Camel Hair
Webb and Son

Bending Machines, Pipe:
Wicksteed, C., and Co., Ld

Blondins and Cableways:
Bullivant and Co., Ld
Henderson, J. M., and Co.

Blowers:
Baker Blower Engineering Co
Drum Engineering Co
Hodges and Co

Boiler Composition:
Bell's Asbestos Co., Ld

Boiler Covering:
Adjustable Boiler Hook Co
Kenyon, W., and Sons, Ld
Leroy, F., and Co
United Asbestos Co., Ld

Boiler Insurance:
National Boiler Insurance Co
Vulcan Boiler Insurance Co

Boiler Mountings:
Galloways Limited
Hopkinson, J., and Co., Ld

Boiler Setting:
Ridley Bros

Boilers:
Abbott and Co., Ld
Babcock and Wilcox, Ld
Beeley, T., and Son
Blake Boiler and Wagon Co
Clarke, Chapman and Co., Ld
Clayton, Son and Co., Ld
Cochran and Co., Annan, Ld
Cochrane, Jno.
Coltman, H., and Sons
Davey, Paxman and Co., Ld
Davy Bros., Ld
Dodman, A., Ld
East Ferry Road Eng'g Co
Farrar, A.
Fawcett, Preston and Co., Ld
Galloways Limited
Grantham Boiler & Crank Co
Hornsby, R., and Sons, Ld
Normand's Patents
North-Eastern Marine Engineering Co
Olrick, L., and Co
Plenty and Son, Ld
Robey and Co., Ld
Ross and Duncan
Ruston, Proctor and Co., Ld
Simpson, Strickland & Co., Ld
Sinclair, Geo.
Spencer, W. H., and Co
Stirling Boiler Co., Ld
Thompson, J.
Thorneycroft, J. I., & Co., Ld
Tinker, Shenton and Co., Ld
Turner E. R. and F., Ld
Yarrow an Co., Ld

Bolts, Nuts, and Fastenings:
Armstrong, Stevens and Son
Baylis, Jones and Baylis, Ld
Cooper, G., and Sons, Ld
Lanarkshire Bolt & Rivet Co
Mercer, E
Winder, R. H.

Books:
Constable A., and Co
Griffin, C., and Co., Ld
Lockwood, Crosby, and Son
Longmans, Green and Co
Spon, E. and F. N., Ld
Whittaker and Co

Brakes:
Consolidated Brake & Eng. Co
Vacuum Brake Co., Ld

Brick and Tile Machinery:
Bennett and Sayer
Bradley and Craven, Ld
Brightside Foundry & Eng. Co
Sutcliffe Speakman and Co

Bridges:
Arrol, Sir W., and Co., Ld
Arrol's Bridge & Roof Co., Ld
Bruce and Still, Ld
Cleveland Bridge and Engineering Co
Finch, E., and Co., Ld
Findlay, A., and Co
Handyside and Co., Ld
Heenan & Froude, Ld
Hornsley Co., Ld
Lysaght, J., Ld
Morton, F., and Co., Ld
Motherwell Bridge Co., Ld
Orr, Watt and Co., Ld
Shewell, J., and Co

Cable (Electric):
Johnson and Phillips

Calculators:
Grimme, Natalis, and Co

Capstans:
Carrick and Wardale

Case Hardening:
Durvite Limited

Cask Making Machinery:
Ransome, A., and Co., Ld

Castings:
Allen, E., and Co., Ld
Bradley, T. and W., Ld
Brit. Westinghouse Elec. Co
Cammell, Laird and Co., Ld
Darlington Forge Co., Ld
Firth, T., and Sons, Ld
Herbert, A., Ld
Lilleshall Co
Rennie's Steel Castings Co
Smith, T., and Co., Ld
Thornton and Crebbin, Ld
Walmsley, A. R., and Co

Centrifugals:
Pott, Cassels and Williamson

Chains:
Dale, William
Gilbert Little Co., Ld

Clutches:
Coil Clutch Co., Ld

Coal and Coke:
Newton, Chambers, & Co., Ld
Talk o'th Hill Colliery, Ld

Coal Cutting Machinery:
Chambers, Scott and Co

Collars, Split Grip:
Carver, C. F., Ld
Trier Brothers

Components:
Waterson, H., and Son

Condensers:
Caird and Rayner
Clarke Chapman and Co., Ld
Cole, Marchent & Morley, Ld
Contraflo Condenser Co., Ld
Edwards Air Pump Syndicate, Ld
Fawcett, Preston and Co., Ld
Fraser, D., and Sons
Haste Pump Co., Ld
Korting Brothers, Ld
Klein Engineering Co., Ld
Ledward and Beckett, Ld
Mirrlees Watson Co., Ld
Wheeler Condenser Co
Willans and Robinson, Ld

Conveyor Belts:
Reddaway, F., and Co., Ld

Conveyors:
Bennis, E., and Co., Ld
Blake, Barclay and Co
Conveyor and Elevator Co
Gilbert Little Co., Ld
Graham, Morton and Co
Hardy Patent Pick Co., Ld
Lidgerwood Mfg. Co
New Conveyor Co., Ld
Robson, G., and Co

Cooling Towers:
Balcke and Co

Couplers, Automatic:
Laycock, W. S., Ld

Cranes:
Appleby Ld
Booth, Jos., & Bros. (Rodley)
Broadbent, T., and Sons
Chaplin, A., and Co
Coles, H. J., Ld
Cowans, Sheldon and Co., Ld
Craven Brothers, Ld
Fielding and Platt, Ld
Gibbins, R. C., and Co
Grafton and Co.
Grieve, J., and Co
Henderson, J. M., and Co.
Heywood, S. H., and Co., Ld
Higginbottom and Mannoex, Isles Ld
Leeds Engineering & Hydraulic Co
Marshall, Fleming and Jack
Morgan, W., and Co
Musker, C. and A., Ld
Ransomes and Rapier, Ld
Russell, G., and Co
Smith, T., and Sons (Rodley)
Taylor and Hubbard
Wilson, J. H., and Co., Ld

Crucibles:
Douiton and Co., Ld

Destructors:
Heenan and Froude, Ld
Meldrum Bros., Ld

Diving Apparatus:
Barnett and Foster
Siebe, Gorman and Co., Ld

Dredge Plant:
Ferguson Brothers
Fleming and Ferguson, Ld
Lobnitz and Co., Ld
Priestman Bros., Ld
Simons, W., and Co., Ld
Smulders, A. F.

Drop Forgings and Stampings:
Armstrong, Stevens and Son
Brooks, J. B., and Co
Kirlew Bros., Ld

Drop Hammers:
Brett's Patent Lifter Co., Ld

Electricity:
Auto-Controllers & Switch Co
Brit. Westinghouse Electric Co
Bruce Peebles and Co., Ld
Crompton and Co., Ld
Dick, Kerr and Co., Ld
Fowler, J., and Co., Ld
Gimson and Co., Ld
Hall, J. P., and Co
Hart, A., and Co
Hartnell, W., and Co., Ld
Hill, G., and Co
India-rubber, Gutta Percha & Telegraph Works Co., Ld
Laurence, Scott and Co., Ld
Mather and Platt, Ld

Electricity (*continued*)
Parker Thomas Ld
Royce Limited
Scott and Mountain, Ld
Tangyes Limited
Verities Limited

Elevators:
Conveyor and Elevator Co
Hardy Patent Pick Co., Ld

Emery, Emery Wheels, &c.:
Carborundum Co
London Emery Works Co
Luke and Spencer, Ld
Mitchell's Emery Wheel Co
Oakey, J., and Sons
Rowland, B. R., and Co
Sterne, L., and Co., Ld

Engine & Boiler Fittings, &c.:
Bailey, W. H., and Co., Ld
Bell's Asbestos Co., Ld
Hopkinson, J., and Co., Ld
Hulburd Engineering Co
Klinger, R., and Co

Evaporators:
Davie and Horne
Liverpool Engineering and Condenser Co., Ld
Normandy's Fresh Water Co

Excavators:
Priestman Bros., Ld
Whitaker Brothers, Ld
Wilson, J. H., and Co., Ld

Expanded Metal:
New Expanded Metal Co., Ld

Fans and Turbines:
Allen, W. H., Son & Co., Ld
Buffalo Forge Co
Davidson and Co., Ld
Dryadale and Co., Ld
Escher, Wyss and Co., Ld
Gilkes, G., and Co., Ld
Gunther, W., and Sons
Keith and Blackman Co., Ld
Musgrave and Co., Ld
Parsons, C. A., and Co
Russell, S., and Sons
Thwaites Brothers, Ld
Waddle Patent Fan and Engineering Co

Feed Pumps:
Caird and Rayner
Sheppee Motor Co

Feed-water Heaters
Clarke, Chapman and Co., Ld
Holden and Brooke, Ld
Royles Limited
Shore, T., and Sons
Weir, G. and J., Ld
Wheeler Condenser and Engineering Co
Wilkinson, Geo.
Wright, Jos., and Co

Fencing:
Baylis, Jones and Baylis, Ld
Bowell, D., and Co

Ferro-Silicon:
British Griffin Chilled Iron & Steel Co., Ld

Filters, Waste Oil:
Wells, A. C., and Co

Fireproof Construction:
New Expanded Metal Co., Ld
Trussed Concrete Steel Co

Fireproof Glass:
Pilkington Bros., Ld

Firewood Machinery
Glover, M., and Co

Flexible Couplings:
Boving, J. Orten

Flexible Shafts:
Electric and Ordnance Accessories Co., Ld

Flooring:
Phœnix Foundry Co., Ld

Flour Mill Machinery
Turner, E. R. and F.

Forced Draught:
Horsfall Destructor Co., Ld
Howden, J., and Co

Forgings:
Clarke's Crank and Forge Co
Darlington Forge Co., Ld
Firth, T., and Sons, Ld
Grantham Boiler & Crank Co
Hardy Patent Pick Co., Ld
Hill and Smith
Ince Forge Co., Ld
Mills, Exors. of J.
Phillips, J., and Co

Foundry Requisites:
Jackman, J. W., and Co

Friction Clutches:
Bagshaw, J., and Sons
Barry, Henry, and Co., Ld
Bridge, D., and Co
Edmeston, A., and Sons
Kay, James C., and Co
Longbotham, R. H., and Co
Unbreakable Pulley Co., Ld
Wellman-Seaver-Morgan Co., Ld
Wigglesworth, F., and Co., Ld

Fuel Economisers:
Clay Cross Co
Lowcock, A., Ld
Roberts Bros
Wilkinson's Coal Economiser and Smoke Comoustion Co

Furnace Bars:
Miller and Co., Ld
Neil, J.

Furnaces:
Brown, J. and Co., Ld
Butterley Co., Ld
Fraser and Chalmers, Ld
Leeds Forge Co., Ld
Meldrum Brothers, Ld

Fusible Plugs:
National Boiler and General Insurance Co

Galvanised Goods:
Butterfield, W. P.

Gas:
Dowson Economic Gas Co., Ld
Power Gas Corporation, Ld

Gas Engines:
British Westinghouse Electric and Manufacturing Co., Ld
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Cundall, R., and Sons, Ld
Daniels, T. H. and J., Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons, Ld
Globe Gas Engine Co., Ld
Grice's Gas Engine Co., Ld
Hasiam Fdry & Eng'g Co., Ld
Hindley, E. B., and Sons
Hornsby, R., and Sons, Ld
Mather and Platt, Ld
National Gas Engine Co., Ld
Premier Gas Engine Co. Ld
Rotsey and Co., Ld
Tangyes Limited

Gauge Glasses
Butterworth Bros., Ld
Guilbert-Martin
Hopkinson, J., and Co., Ld
Moncrieff, J.
Tomey, J., and Sons, Ld

Gauge Glass Protectors:
Hulburd Engineering Co

Gauges:
Bailey, W. H., and Co., Ld
Klinger, R., and Co
Negretti and Zambra
Schaefer and Budenberg, Ld

Gear Cutting:
Brown D., and Sons, Ld

Gearing:
Adams, George
Ahlers, Ad.
Bodley Brothers and Co
Harpers Limited
Henry, J., Ld
Reid Gear Co
Renold, Hans Ld
Unbreakable Pulley Co., Ld

Glass:
Pilkington Bros. Ld

Governors:
Pollock, MacNab & Highgate
Storey, I., and Sons, Ld

Grain Cleaning Machinery:
Boby, R., Ld

Graphite:
Dixon Crucible Co

Grinding Machinery
Atterton J.
Bradley Pulveriser Co
Roberts Bros
Smedley Bros., Ld

Guns and Rifles:
Lancaster, Chas.

Hammers:
Carron Company
Climax Patents, Ld
Davis and Primrose
Massey, B. and S.
Nasmyth, Wilson and Co., Ld
Pilkington, P., Ld
Player, W. and J.
Pollock, MacNab & Highgate
Samuelson and Co., Ld
Thwaites Bros., Ld

Handles:
Burley and Son, Ld

Harbour Plant
Stothert and Pitt Ld
Wilson, John H., and Co., Ld

Haulage Gear:
Clarke, Chapman and Co., Ld

Heating Apparatus:
Browning, W. E., and Co
Buffalo Forge Co
Körting Brothers, Ld

Hinges, Iron:
Crompton, Thomas

Hose:
Merrywesther and Sons, Ld
Moseley, D and Sons, Ld

Hydraulic Leathers:
Ahlers, A.

Hydraulic Machinery:
Adiam, G., and Sons, Ld
Berry, H., and Co., Ld
Davy Bros., Ld
Fielding and Platt, Ld
Holt and Willetts
Leeds Engineering and Hydraulic Co
Musgrave Bros.
Musker, C. and A., Ld
Rice and Co., Ld
Smith, Hugh, and Co
Vacher, H. P.

Hydro-extractors:
Broadbent, T., and Sons
Manlove, Alliott and Co

Igniter, Gas and Oil Engine:
Lodge Bros. and Co

India-rubber, &c.:
India-rubber, Gutta Percha & Telegraph Works Co., Ld
Moseley, D., and Sons, Ld
Reddaway, F., and Co., Ld

Injectors & Ejectors
Davies and Metcalfe, Ld
Green and Boulding, Ld
Gresham and Craven, Ld
Holden and Brooke, Ld
Klinger, R., and Co
Wilcox, W. H., and Co., Ld

Inspect'g Engineers
Price, J.

Insurance
Sun Fire Office
Vulcan Boiler Insurance Co

Iron and Steel Works Plant:
Akrill, C., and Co., Ld
Head, Wrightson and Co.,
Jones, George, Ld
Lowca Engineering Co., Ld
Perry, T., and Son, Ld
Thornton and Crebbin, Ld
Wellman-Seaver-Head

Iron and Steel Buildings & Roofs:
Ash, J., and Son
Ashmore, Benson, Pease & Co
Bagshaw, J., and Sons, Ld
Bain, W., and Co
Barrett, J. T., and Co
Barrowfield Ironworks, Ld
Braby, F., and Co
Brownlie and Murray, Ld
Bruce and Still, Ld
Clayton, Son and Co., Ld
Clyde Structural Iron Co., Ld
Glasgow Steel Roofing Co., Ld
Grover and Co., Ld
Handyside and Co., Ld
Lysaght, J., Ld
Main, A. and J., and Co
Morton, F., and Co., Ld
Piggott T., and Co., Ld
Ralston, Goodwin and Co
Rowell, D., and Co
Walker Brothers, Ld

Jointing:
Dixon Crucible Co
Klinger, R., and Co
Walker, J., and Co

Laundry Machinery:
Hill and Herbert, Ld
Summerscales, W., and Sons
Tullis, D. and J., Ld

Lead Machinery:
Krupp Grusonwerk M.

Lifts and Hoists:
Barry, Henry and Co., Ld
Gimson and Co., Ld
Holt and Willetts
Smith and Stevens
Waygood, E., and Co., Ld
Youngs

Light:
U.K. Lighting Trust, Ld
Wells, A. C., and Co

Liquid Air:
British Liquid Air Co. Ld

Locks:
Kaye, J. and Sons, Ld

Locomotives:
American Locomotive Co
Avonside Engine Co
Bagnall, W. G., Ld
Beyer, Peacock and Co., Ld
Borsig, A.
Burnham, Williams and Co
Davies and Metcalfe, Ld
Green, T., and Sons, Ld
Hawthorn, Leslie and Co., Ld
Henschel and Sohn
Hudswell, Clarke and Co
Hunslet Engine Co., Ld
Kerr, Stuart and Co., Ld
Locomotive and Machine Co. of Montreal
North British Locomotive Co., Ld
Peckett and Sons
Stephenson, R., and Co., Ld
Vulcan Locomotive Works

Lubricators:
Hulburd Engineering Co
Trier Bros.
Wakefield, C. C., and Co

Machine Tools (*see* Tools)

Manganese Steel Castings & Forgings
Allen, E., and Co., Ld
Cammell Laird and Co., Ld
Hadfield's Steel Foundry Co

Manholes:
M'Neil, C.
Rolled Steel Forge Co., Ld

Marine Machinery:
Renfrew Bros. and Co

Mathematical Instruments:
Negretti and Zambra
Stanley, W. F. and Co. Ld

Measuring Machines
Newall Engineering Co. Ld

Merchant Iron:
Dunkerley, C. C., and Co. Ld
Farnley Iron Co., Ld
Henderson and Glass
Henschel and Sohn
Measures Brothers, Ld
Pearson and Knowles Coal Co
Whitehouse, H. R., & Sons, Ld

Metal Perforators:
Barns, W. and Sons

Metals:
Atlas Metal & Alloys Co., Ld
British Bronze and Metal Co
Bull's Metal & Melloid Co., Ld
Delta Metal Co., Ld
Magnolia A. F. Metal Co., Ld
Phosphor Bronze Co., Ld
Tandem Smelting Syndicate

Meters:
Glenfield and Kennedy, Ld

Mica:
Wiggins, F. and Sons

Mining Machinery:
Cammell Laird and Co., Ld
Davey, Paxman and Co., Ld
Fraser and Chalmers, Ld
Head, Wrightson and Co., Ld
Heenan and Froude, Ld
Krupp Grusonwerk
Sandycroft Foundry Co., Ld
Walker Brothers, Wigan

Motor Cars:
Evans, A. G., and Co
Mann's Patent Wagon Co
St Pancras Ironworx Co., Ld
Thornycroft, J. I., & Co. Ld

Moulding Machines:
Jackman, J. W., and Co

Oil Cans:
Kaye, J., and Sons, Ld

Oil Engines:
Blackstone and Co., Ld
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons
Globe Gas Engine Co., Ld
Hardy and Padmore, Ld
Hornsby and Sons, Ld
Mirrlees Watson Co., Ld
Tangyes Limited
Vosper and Co., Ld

Oil Extractors:
Baker's Patent Appliances, Ld
Haigh, W. B., and Co., Ld
Holden and Brooke, Ld

Oil-gas Apparatus:
Mansfield and Sons, Ld

Oil Launches:
Vosper and Co., Ld

Oil Mill Machinery:
Rose, Downs & Thompson, Ld

Oils and Lubricants:
Price's Patent Candle Co
Snowdon, Sons and Co
Stern-Sonneborn Oil Co
Trier Brothers
Wakefield, C. C., and Co

Oil Separators:
Rowland, B. R., and Co., Ld

Packing, Metallic:
Green and Boulding, Ld
Hobdell, Way and Co., Ld
Hudson, J., & Co., Successors
Hulburd Engineering Co
Klinger, R., and Co
Lancaster and Tonge, Ld
Moseley, D., and Sons, Ld
United Asbestos Co., Ld
U.K. Metallic Packing Synd.
U.S. Metallic Packing Co., Ld
Walker, J., and Co

Paints:
Morris and West

Painting Machines:
Wells, A. C., and Co

Patent Agents:
Alexander, E. P., and Son
Harris and Mills
Jensen and Son
Redfern, G. F., and Co
Roote, J. D., and Co
Vaughan and Son
Watkins, Son and Groves

Patent Fuel Plants:
Richards and Thompson, Ld

Pattern Makers:
Brown, D., and Sons Ld,

Photo Printing:
Haldane, J., and Co., Ld
Hall, R. J., and Co., Ld

Pig Iron:
Brown, J., and Co. Ld
Clay Cross Co
Lilleshall Co

Piles:
British Steel Piling Co

Pipes, Iron & Steel:
Clayton, Son and Co., Ld
Meehan and Sons
Piggott, T., and Co., Ld
Stewarts and Lloyds, Ld

Pipe Joints:
Macnaughtan Bros

Pile Drivers:
Nasmyth, Wilson and Co., Ld

Pistons:
Lancaster and Tonge, Ld
Lockwood and Carlisle, Ld
M'Neil, C., jun.

Plates, Steel:
Glasgow Iron & Steel Co., Ld

Plummer Blocks:
Jardine, J.
Unbreakable Pulley Co., Ld

Pneumatic Tools:
Climax Patents, Ld
Consolidated Pneumatic Tool Co., Ld
Globe Pneumatic Engineering Co., Ld
Howard Pneumatic Eng'g Co
Ingersoll-Rand Co

Pressed Work:
Phœnix Foundry Co., Ld

Presses:
Davy Bros., Ld
Hands, J., and Sons, Ld
Mirfield Engineering Co., Ld
Rhodes, J., and Sons, Ld
Taylor and Challen, Ld

Printing:
Severn, Geo.

Pulleys:
Jagshaw, J., and Sons, Ld
Douglas, Lawson and Co
Garnett, P. and C., Ld
Gimson and Co., Ld
Harpers Limited
Mork Patent Pulley Block Co
Smith and Grace
Thompson & Southwick, Ld
Wiggisworth, F., and Co., Ld

Pulverisers and Quartz Mills:
Bradley Pulveriser Co

Pumps:
Allen, W. H., Son and Co., Ld
Batchelor, R. D.
Berrans Ld
Brackett, F. W., and Co
Cameron, J., Ld
Carrick and Wardale
Carruthers, J. H., and Co
Cochrane, John
Drum Engineering Co
Dryadale, J., and Co
Entwisle and Gass, Ld
Evans, J. and Sons
Fleming and Ferguson, Ld
Glenfield and Kennedy, Ld
Gwynnes Limited
Hall, J. P., and Sons, Peterboro
Haste Pump Co., Ld
Hathorn, Davey and Co., L
Hayward-Tyler and Co
Hughes and Lancaster
Mumford, A. G., Ld
Owens, S., and Co
Parker, Thos., Ld
Pearn, F., and Co., Ld
Pulsometer Engring Co., Ld
Reader, E., and Sons, Ld
Richards, R., and Co
Simpson, J., and Co., Ld
Tangyes Limited
Thwaites Brothers, Ld
Warner, R., and Co., Ld
Weir, G. and J., Ld
Westinghouse Brake Co., Ld
Wilcox, W. H., and Co., Ld
Worthington Pump Co., Ld

Railway Plant:
Askham Bros. and Wilson, Ld
Bagnall, W. G., Ld
Baker, J., and Co. (Rotherham)
Birch, J. and Co., Ld
Bolling and Lowe
Continuous Rail Joint Co
Cravens, Limited
Dick, Kerr and Co., Ld
Findlay, A., and Co
Fowler, J., and Co., Ld
Glasgow Railway Engin'g Co
Griffith, W., and Sons
Hartley and Co
Harrison and Camm, Ld
Hillen Steel Rail Works
Hudson R.
Ince Foundry Co
Kerr, Stuart and Co., Ld
Koppel, A
Laycock, W. S., Ld
Leeds Forge Co., Ld
Lion Spring Co
Maclellan, F. and W., Ld
Marple and Gillott
McLachlan and Co
Midland Railway Carriage Co
Patent Shaft and Axletree Co
Pickering, R. Y., and Co., Ld
Purvey, T.
Ransomes and Rapier, Ld
Renshaw, W. R., and Co., Ld
Stableford and Co
Summerson, T., and Sons, Ld
Turner, G. R., Ld
United Electric Car Co., Ld

Rams, Hydraulic:
Bailey, W. H., and Co., Ld
Vacher, H. P.

Reducing Valves:
Royles Limited

Refrigerating Machinery:
Farringdon Works and H. Pontifex and Sons, Ld
Hall, J. and E., Ld
Haslam Foundry and Engineering Co., Ld
Linde British Refrigeration Co
Pulsometer Engineering Co
Sterne, L., and Co Ld

Reinforced Concrete
Trussed Concrete Steel Co., Ld

Rivets:
Lyall Brothers

Rock Drills:
Daw, A. and Z.

Rolls and Rolling Mill Plant
Akrill, C., and Co., Ld
Krupp-Grusonwerk, F
Tennent, R. B. Ltd

Roofs (*see* Iron Build'gs)

Sand Washers:
Hardy and Padmore, Ld

Saw Mill Machinery (*see* Woodworking Machinery)

Screwing Tackle:
Chatwin, T.
Heap, Joshua, and Co., Ld
Hulse and Co., Ld
Widdowson, J. H.
Williamson, J.

Shafting:
Carver, C. F., Ld
Govan Shafting Co
Hardy Patent Pick Co., Ld
Harpers Limited
Mackies, Ld
Platt, S., Ld

Shearing Machines:
Jones, Geo., Ld
Perry, T., and Son, Ld

Soda Water Machinery:
Barnett and Foster

Springs:
Lancaster and Tonge, Ld
Tempered Spring Co., Ld

Steam Engines:
Brazil, Straker and Co., Ld
Brearley, Fairbank, Ld
Brit. Westinghouse Electric Co
Burrell, C., and Sons
Cole, Marchent & Morley, Ld
Dodman, A., Ld
Easton and Bessemer, Ld
Galloways Limited
Heenan and Froude, Ld
Hindley, E. B., and Sons
Howden, J., and Co
Lees, T. and R.
Plenty and Son, Ld
Ransomes, Sims and Jefferies
Reader, E., and Sons, Ld
Reavell and Co., Ld
Robey and Co., Ld
Ross and Duncan
Ruston, Proctor and Co., Ld
Samuelson and Co., Ld
Stewart, D., and Co., Ld
Sulzer Bros
Swiss Company, Ld
Tangyes Limited
Turner, E. R. and F., Ld
Wilson, A.

Steam Launches:
Cosseras and Co., Annan, Ld
Fleming and Ferguson Ld
Hayes, Ed
Lobnitz and Co., Ld
Salter Bros.
Simons, W., and Co., Ld
Simpson, Strickland and Co
Yarrow and Co., Ld

Steam Separators:
Haigh, W. B., and Co
Holden and Brooke, Ld
Lancaster and Tonge, Ld

Steam Traps
Geipel and Lange
Hobdell, Way and Co Ld
Lancaster and Tonge, Ld
Royles Limited

Steel:
Allen, Edgar, and Co., Ld
Armstrong, Whitworth & Co
Beardmore, W., and Co
Brit. Westinghouse Electric Co
Brown, Bayley's Stee. Works,
Brown, J., and Co., Ld
Butterley Co., Ld
Carbrook Steel Works
Colville, D., and Sons, Ld
Firth, T., and Sons, Ld
Glasgow Iron & Steel Co., Ld
Hadfield's Steel Foundry Co
Howell and Co., Ld
Jessop, W., and Sons, Sheffield
New Coleshill Works Co
Nicrobalt Steel Co
Rogerson, J., and Co
Spencer, J., and Sons
Steel Company of Scotland
Stewarts and Lloyds, Ld
Turton, T., and Son
Vickers, Sons and Maxim, Ld

Steel Structural Work:
Ashmore, Benson, Pease & Co
Main, A. and J., and Co
Meehan and Sons, Ld
Morton, F., and Co., Ld
Walker, C. and W., Ld

Stills and Distilling Plant:
Blair, Campbell and McLean
Pontifex and Wood

Stokers, Mechanical, &c.:
Bennis, E., and Co., Ld
Haigh, W. B., and Co
Meldrum Bros., Ld
Proctor, Jas.
Triumph Stoker, Ld

Stone Breakers:
Baxter, W. H., Ld
Goodwin, Barsby and Co
Marsden, H. R.
Mason Bros.

Suction Gas Plant (*see* Gas Engines)

Sugar Machinery:
Blair, Campbell & McLean, Ld
Craig, A. F., and Co., Ld
Maniove, Alliott and Co. Ld
Mirrlees Watson Co., Ld
Pott, Cassels and Williamson
Stewart, D., and Co., Ld

Superheaters:
Cruse Superheater Co
Galloways Limited

Surveying Instruments:
Clarkson's
Stanley, W. F., and Co., Ld

Tanks:
Ash, J., and Son
Braby, F., and Co., Ld
Butterfield, W. P.
Newton, Chambers & Co., Ld

Time Checkers:
Llewellin's Machine Co

Tools:
Alma Machine Tool Works
Archdale, J., and Co
Asquith, W., Ld
Bennis, J., and Sons
Buck and Hickman, Ld
Buckton, J., and Co., Ld
Burton, Griffiths and Co
Butler, J., and Co
Cameron, J., Ld
Campbells and Hunter
Carron Company

Tools (*continued*):
Chambers, Scott and Co
Clifton and Waddell
Cohen, L., and Co
Craven Bros., Ld
Crosier, Stephens & Co
Cunliffe and Croom, Ld
Dantell, S. A., Ld
Darling and Sellers, Ld
Davis and Primrose
Dean, Smith and Grace, Ld
De Bergue and Co., Ld
Dempster, Moore and Co., Ld
Drummond Bros., Ld
Heap, J., and Co. Ld
Herbert, A., Ld
Hetherington, J., & Sons, Ld
Hill, Isaac and Son
Hill, J. and F.
Hulse and Co., Ld
Jones & Lamson Machine Co
Kendall and Gent, Ld
Lang, J., and Sons
Loewe, L., and Co., Ld
Low Moor Co., Ld
Muir, W., and Co
Neville Machine Tool Co. Ld
Noble and Lund, Ld
Parkinson, J., and Son
Pfeil and Co.
Platt, S., Ld
Pratt, F., and Co., Ld
Redman, C., and Sons
Reinecker, J. P.
Richards, G., and Co.,
Ryder, T., and Son
Schuchardt and Schutte
Shanks, T., and Co
Smith and Coventry, Ld
Smith, Hugh, and Co., Ld
Stirk, J., and Sons
Tangyes Limited
U.S. Metallic Packing Co., Ld
Ward, H. W., and Co
Ward, T. W., Ld
Webster and Bennett
Wilkinson, G., and Sons

Traction Engines
Burrell, C., and Sons, Ld
Fowler, J., and Co. (Leeds
Ransomes, Sims and Jefferies

Translators:
Crow, C. J.

Tube-making Machines
Fielding and Platt, Ld
Jones, George, Ld

Tube Mills:
Newell, E., and Co., Ld

Tubes:
Birmingham Battery Co
British Mannesmann Tube Co
Broughton Copper Co., Ld
Galloways Limited
Grice, Grice and Son
Howell and Co., Ld
Lewis, E., and Sons
Piggott, T., and Co., Ld
Russell, James, and Sons, Ld
Russell, Jno., and Co., Ld
Stewarts and Lloyds, Ld
Weldless Steel Tube Co., Ld

Turbines, Steam:
Gwynnes Ld
Mather and Platt, Ld
Willans and Robinson, Ld
Parsons, C. A., and Co

Turbines, Water (*see* Fans)

Turnstiles,
Iaser, C., and Co
Le Grand and Sutcliff

Vacuum Pumps:
Brackett, F. W., and Co
Lacy-Hulbert and Co., Ld
Reavell and Co., Ld

Valve Makers:
Alley and Macleilan, Ld
Ashton Valve Co
Auld, D., and Son
Baldwin, J., and Co
Breuer, H., and Co
Dermatine Co., Ld
East Ferry Road Eng'g Co
Lunken Valve Co
Turnbull, A., and Co., Ld
Walls Valve Mfg. Co

Ventilators:
Browning, W. E., and
Boyle, R., and Son

Vulcanite:
Winter, F.

Warships and Merchant Ships:
Cammell, Laird and Co., Ld

Washers:
Grover and Co., Ld

Water Coolers:
Harrison, J. H.

Water Purification and Softening
Baker's Patent Appliances Co
Glover and Robson, Ld
Kennicott Water Soft'ng
Lassen and Hjort
Mather and Platt, Ld
Paterson Engineering
Pulsometer Engineering Co
Royles, Ld

Water Wheels (*see* Fans)

Weighing Machinery:
Bennis, E., and Co., Ld
Denison, S., and Son, Ld
Spencer, Jas., and Co

Welding:
Thermit Limited

Wheels:
Brown, D., and Sons, Ld
Henry, Joseph, Ld
Urquhart, Lindsay & Co., Ld

Wind Engines:
Warner, R., and Co., Ld
Williams, Alfred, and Co

Windlasses:
Wilson, J. H., and Co., Ld

Wire & Wire Ropes
Allan, Whyte and Co
Bullivant and Co., Ld
Cooke, W., & Co., Ld
Fredock, G., and Co
Elliot, G., and Co., Ld

Wire (Insulated)
Johnson and Phillips

Wood:
Irwin, R. C.

Wood Engravers:
Swain, John, and Son, Ld

Wood-Framing:
Lotz, Murray, and Co

Wood Screws and Rivets
Guest, Keen & Nettlefolds, L

Woodworking Machines
Ransome, A., and Co., Ld
Robinson, T., and Sons, Ld
Wadkin and Co

Fuller, Horsey, Sons & Cassell,

BILLITER SQUARE, LONDON, E.C.
ESTABLISHED 1807.
AUCTIONEERS, VALUERS, AND SURVEYORS
OF
MILLS AND MANUFACTORIES,
PLANT AND MACHINERY,
WHARVES AND WAREHOUSES.

Telegraphic Address—"Fuller Horsey, London."
Telephone No. 746 Avenue. BK29

Railway Switches and Crossings,

TURNTABLES, WATER CRANES, TANKS, PIPES, BRIDGES, AND ROOFS.
ISCA FOUNDRY and ENGINEERING CO., Newport, Mon.
London Office: 16 and 17, Devonshire-square, Bishopsgate-street, E.C. (Spl) nx158

For Sale, Theodolites,

DRAWING INSTRUMENTS. SECOND-HAND.
CLARKSON'S, 338, High Holborn, W.C.
(opposite Gray's-inn-road)

For Sale, Levels,

DRAWING INSTRUMENTS. SECOND-HAND.
CLARKSON'S, 338, High Holborn, W.C.
(opposite Gray's-inn-road) P132

For Sale, Turntables, Good

Second-hand, for main line wagons, with cross roads.
LOCO. CRANE, 2½ tons, 4ft. 8½in. gauge; only used about 10 days.
Several 30 and 40 H.P. Loco. Type SEMI-PORTABLE BOILERS.
15-Ton Goliath CRANE, 54ft. 10½in. span.
RAILS, New and Second-hand, all sections.
SLEEPERS, New and Second-hand, plain and creosoted.
POINTS and CROSSINGS, TIP WAGONS, &c.
RENTON AND CO.,
MIDLAND WORKS,
SHEFFIELD. Spl 30/6

For Sale, 4 H.P. Vertical Engine

and BOILER, by Wallis and Stevens.—H. H. GARDAM, Staines, Middlesex. P151*

For Sale, 12 H.P. Double-cylinder

PORTABLE ENGINE, by Marshall; 8 H.P. DITTO, 4 H.P. DITTO, by Davey Paxman.—H. H. GARDAM, Staines, Middlesex. P150

For Sale, 12 H.P. Semi-portable

ENGINE (Undertype), by Marshall; first-class condition; insured for 120 lb. working pressure.—H. H. GARDAM, Staines, Middlesex. P149

For Sale, 12 H.P. Semi-portable

(Overtype), by Clayton Shuttleworth; in first-class working order; ready for immediate use.—H. H. GARDAM, Staines, Middlesex. P149

For Sale, 12in. Saddle Tank

LOCOMOTIVE, six wheels coupled, by Manning Wardle and Co., rebuilt by makers and equal to new. Two VERTICAL COMPOUND BLAKE-KNOWLES STEAM PUMPS, steam cyls. 12in. and 20in. dia., water cyl. 22in. dia., stroke 18in.; practically new.—R. H. LONGBOTHAM and CO., Ltd., Ings Foundry, Wakefield. 2052

Machinery for Sale and Wanted.

—Before Buying or Selling, save money by sending for the *Machinery Market*—the chief machinery trading medium in the Country, and the most direct.—Biggest selection in U.K. of ENGINES, BOILERS, MACHINE TOOLS, CRANES, PUMPS, MOTORS and MACHINERY of every description, second-hand and new in stock.—Offices: 146a, Queen Victoria-street, London, E.C. Single copy 1½d., post free; or 1d. every Friday from newsagents. 2058

Magnificent Screw-driven Planing

MACHINE, to plane 20ft. long × 8ft. broad × 6ft. high, with six tool-boxes, four of which are carried on the cross slide and one on each standard. One of the tool-boxes on the cross slide is arranged for cross planing.
A thoroughly modern and up-to-date tool, in excellent condition. Weight 53 tons. Makers, F. and J. Butterfield, Ltd., Keighley. Can be inspected in Nottingham. Price low for immediate removal. Apply—
THE MACHINE TOOL COMPANY, LTD.,
LONDON-ROAD, NOTTINGHAM. Z190
Telegrams: "Value, Nottingham." Telephone: No. 107.

MESSRS. LEE & HUNT

CROCUS-STREET, NOTTINGHAM,
Have just purchased, near London, the
COMPLETE PLANT OF A BOILERMAKER AND ENGINEER,
Including HYDRAULIC RIVETTERS (Fixed and Portable), PLATE-BENDING ROLLS, RADIAL and BOILER-SHELL DRILLS, PUNCHES and SHEARS, PLATE PLANER, HYDRAULIC PRESSES and PUMPS, RIVET-MAKING MACHINE, ENGINES, BOILERS, CRANES, &c. &c., and are offering same PIECEMEAL at EXCEPTIONALLY LOW PRICES to avoid second carriage.—May be inspected on application to LEE and HUNT, NOTTINGHAM. 2059

NEW MACHINE TOOLS.

RADIALS, PLANERS, LATHES, SLOTTERS,
PUNCHES AND SHEARS, SHAPING MACHINES,
ANGLE-IRON BENDERS, &c.
AUTOMATIC WHEEL CUTTING MACHINE.
Large Stock. Moderate Prices
Send for List. Inspection invited.
G. F. SMITH, LIMITED, HALIFAX.
Telegrams, "Radial. D30 Telephone 71

Nearly New Screw Planing

MACHINE for SALE, to plane 6ft. long by 2ft. 6in. square, with one tool-box; cutting speed 30ft. per minute; return speed 70ft.; can be seen at work.—J. BUTLER and CO., Victoria Ironworks, Halifax. 2054

Second-hand Lathe for Sale, 9in.

centre by 12ft. bed, sliding and surfacing, by Butterfield, with overhead motion complete; OFFERS WANTED for immediate clearance.—HUNT and MITTON, Ozzells-street North, Birmingham. 925

Tools in Progress of Delivery in

seven days, 26in. and 18in. swing BORING and SURFACING LATHES; and One 7½in. centre sliding, SURFACING and SCREW-CUTTING LATHE, 8ft. gap bed; One 24in. High-speed DRILL.—A. HAWORTH'S SONS, Sowerby Bridge, England. 2042

4 Babcock and Wilcox Boilers,

two 75 H.P. and two 100 H.P.; insured for 150 lb. per square inch; replaced by larger plant; cheap.—Address, P187, Engineer Office, 33, Norfolk-street, Strand, W.C. P187

30 H.P. Oil Engine, by Cundall,

modern, nearly new, self-starter; two 6ft. fly-wheels, pulleys, &c.; fine engine; cheap to save cost removal.—POLLOCK, BROWN and CO., Southampton. 862

THE EDWARDS
PATENT AIR PUMP.

3 and 5, CROWN COURT, OLD BROAD STREET E.C.
For Large Advertisement see Dec. 6th (page 72). (Spl) nx98

YARROW'S WATER-TUBE BOILERS.

ILLUSTRATED ADVERTISEMENT APPEARING THIRD ISSUE OF EACH MONTH.
LONDON and GLASGOW. (Spl) nx28

CHARLES GRIFFIN & CO., LTD., PUBLISHERS.

JUST READY. A Companion Volume to "Dock Engineering." In large 8vo. Cloth. With Plates and Illustrations.
THE PRINCIPLES AND PRACTICE OF
HARBOUR ENGINEERING.
By BRYSSON CUNNINGHAM.

CONTENTS.—Introductory—Harbour Design—Surveying, Marine and Submarine—Piling—Stone, Natural and Artificial—Breakwater Design—Breakwater Construction—Pierheads, Quays and Landing Stages—Entrance Channels—Channel Demarcation—Index.

In large 8vo. Handsome Cloth. With 34 Folding Plates and 468 Illustrations. 30s. net.
THE PRINCIPLES & PRACTICE OF DOCK ENGINEERING.
By BRYSSON CUNNINGHAM.

"We have never seen a more profusely illustrated treatise. It is a most important standard work, and should be in the hands of all dock and harbour engineers."—*Steamship.*

THE DESIGN OF STRUCTURES. By S. ANGLIN, C.E. Fourth Edition, Revised. With numerous Diagrams, Examples, and Tables. In large 8vo., cloth. 16s.

BRIDGE CONSTRUCTION: A PRACTICAL TREATISE ON. By T. CLAXTON FIDLER. Third Edition. Thoroughly Revised, with numerous Illustrations and Plates. 30s.

Second Edition, thoroughly Revised and Enlarged. Re-written. 15s net.
CALCAREOUS CEMENTS:
THEIR NATURE, PREPARATION, AND USES.
By G. R. REDGRAVE, Assoc. Inst C.E., and CHARLES SPACKMAN, F.C.S.

"Well illustrated . . . forms one of the standard works on the subject."—*Building News.*

BLASTING: AND THE USE OF EXPLOSIVES. By OSCAR GUTTMANN, M. Inst. C.E., F.I.C., F.C.S. Second Edition, Revised, with Plates and Illustrations. 12s. 6d.

MANUAL of CIVIL ENGINEERING. By W. J. MACQUORN RANKINE, LL.D., F.R.S. Twenty third Edition. In Crown 8vo., cloth. Illustrated. 16s. nx303

LONDON: CHARLES GRIFFIN & CO., LTD., EXETER STREET, STRAND, W.C.

Bagshaw's Wrought Iron Pulleys,

as used in Government departments, are the strongest, cheapest, and best in the market. Quick delivery given. Illustrated price list, containing rules for transmission of power by wheels, belts, ropes, and shafts free.—J. BAGSHAW and SONS, Limited, Engineers, Batley, Yorkshire. O117a

Edwards Air Pumps.—Two Pairs

of 30in. dia. × 12in. stroke. Edwards Dry AIR PUMPS for SALE, brass lined, each pair fitted with 8in. wet pump, 10in. stroke, steam cylinders 10in. and 15in. / 12in., adapted for working compound. In good condition, done about 2½ years' work.—Address inquiries and offers to AIR PUMP, The Abbw Vale Steel Iron and Coal Co., Ltd., Ebbw Vale, R.S.O., Mon. 2018

Vosper and Co., Ltd., Engineering

WORKS, BROAD-STREET, PORTSMOUTH.
COMPOUND SURFACE CONDENSING LAUNCH ENGINES IN STOCK, READY FOR IMMEDIATE DELIVERY:—

Cylinders	in.		in.				
2½ and	5	diameter	× 4	stroke,	Admiralty	pattern.	
,, 3	,, 6	,,	× 5	,,	,,	,,	
,, 3½	,, 7½	,,	× 5	,,	,,	,,	
,, 4½	,, 9	,,	× 5	,,	,,	,,	
,, 5½	,, 11½	,,	× 7	,,	,,	,,	
,, 6	12	,,	× 7	,,	,,	,,	

ONE TRIPLE-EXPANSION, cylinders 4½in. and 8½in. and 14in. × 9in. stroke. Suitable Boilers, either Vertical, Horizontal, or Water-tube, for all the above. STEAM LAUNCHES complete, 22ft., 30ft., and 32ft. All size MOTORS and MOTOR BOATS in stock or in progress. New designs and highest class workmanship. Catalogues and full particulars on application 2055

50 B.H.P. Gas Engine for Sale,

with or without Suction Gas Plant.—Can be seen working with town or suction gas, at JOHN CAMERON, Limited, Oldfield-road Ironworks Salford. 2057

The Proprietor of the Patent No.

27300 A.D. 1904, relating to Improvements in Sieves or Screens for use in Separating Ores and other Granular Minerals, DESIRES to GRANT LICENCES to interested parties.
Enquiries to be addressed to—
CLEMENT LEAN, B.Sc., A.M.I. Mech. E., Chartered Patent Agent, Thanet House, 231, Strand, London, W.C. P191

Gas Engines and Suction Plants.

—EXPERT ADVICE. Inspections, Tests, and Reports. Phone: 1360 East. Tel.: "Rapidising, London."—E. J. DAVIS, A.M.I. Mech. E., Great Eastern-road, Stratford, E. P673

German and French Technical

PAPERS, CATALOGUES, SPECIFICATIONS, &c., TRANSLATED into English and vice-versâ.—C. J. CROW, 19, Woodland-road, New Southgate, N. P38

R. Heber Radford, Son & Squire

ENGINEERING, IRON, and STEEL WORKS
VALUERS,
CONSULTING ENGINEERS, REFEREES, AND ARBITRATORS.
Established over 40 years.
(Senior partner, R. Heber Radford, Mem. Inst Mechanical Engineers, Mem. Inst Naval Architects, Mem. Iron and Steel Institute, Fellow Chartered Institute of Patent Agents.)
15, ST. JAMES-ROW, SHEFFIELD.
Telegrams: "Radford, Sheffield." Telephone: 416. (Spl) 30

Titley and Wall,

Consulting Engineers and Valuers,
TUBE AND ROLLING MILL EXPERTS,
Paradise street, Birmingham. T101a

A Firm of Engineers, having an

exceptional connection among the leading railways (British, Indian, and Colonial), is PREPARED to CONSIDER, with a view to Undertaking their Manufacture and Sale, any SUITABLE SPECIALITIES.—Communications, which will be treated in strict confidence, to be sent, in the first instance, to 2043, Engineer Office, 33, Norfolk-street, Strand, W.C. 2043

A Firm of Engineers, about 30

miles from London, now manufacturing a Speciality for well-known London Company, are OPEN to MANUFACTURE another SPECIALITY.—Address, P204, Engineer Office, 33, Norfolk-street, Strand, W.C. P204

Inventors Desiring to Find a

Manufacturer on Royalty or a Purchaser of their INVENTIONS should apply to J. D. ROOTS and CO., Thanet House, Temple Bar, London, one branch of whose business is that of bringing together the Inventor and the Capitalist. Advice given on all new Inventions without charge. 4212

Large Engineering Firm of High

Standing is OPEN to UNDERTAKE ENGINEERING and BOILER WORK of a Repetition or Miscellaneous character, in any quantity; main line and other locomotive repairs expeditiously carried through. Prompt delivery and high-class workmanship guaranteed, and inspection of manufacturing facilities invited.—Address, 359, Engineer Office, 33, Norfolk-street, Strand, W.C. 359

To Foreign Manufacturers.—In

order to keep your English Patents valid, under new Patent Law, you must manufacture in England. Large FIRM of ENGINEERS are OPEN to UNDERTAKE this FOR YOU.—Address, in first instance, to 722, Engineer Office, 33, Norfolk-street, Strand, W.C. 722

FULLER, HORSEY, SONS and CASSELL
Make a speciality of the SALE and LETTING of
FACTORIES, WHARVES AND WAREHOUSES,
and are the only firm who deal EXCLUSIVELY with manufacturing property as distinct from dwelling-houses and residential estates. A copy of their printed Register (the largest and oldest established) forwarded on application.
Offices: 11, BILLITER-SQUARE, E.C. 2049

FACTORIES (WITH or WITHOUT PLANT), LAND,

WHARVES, WAREHOUSES, &c.—Largest Register, issued free by LEOPOLD FARMER AND SONS,
Surveyors, Auctioneers, and Specialists in Factory Property, 46, Gresham-street, Bank, E.C., and Kilburn, N.W. nx347

Boilermaking and Constructional

WORKS for SALE as a GOING CONCERN, situate in the North-East of England, in full operation; old-established, and with good connection; on Admiralty and other lists.—For further particulars, apply to Messrs. WOOD and NEWLAND, Engineering Valuers, 42, Spring-gardens, Manchester. 917

ACME ENGINE COMPANY, LIMITED.
(IN LIQUIDATION).
For Sale, by Private Treaty, as

a Going Concern, the GOODWILL, STOCK, PLANT, PATTERNS, and MATERIAL belonging to the above Company.
The works are situated at Shettleston, and have a siding to the North British Railway. They are modern and fully equipped with all requisite plant for the manufacture of gas engines.
The engine manufactured by this company is well and favourably known, and the business has a first-class connection.
Existing contracts for gas engines in course of construction can be taken over by purchaser. The stock, plant, &c., will be taken over at mutual valuation.
For full particulars apply to
THOS. GUTHRIE, C.A., Liquidator,
163, St. Vincent-street, Glasgow. 937

To Engineers, Manufacturers

REMOVING FROM LONDON, AND OTHERS.
FOR SALE, as a GOING CONCERN.
The OLD-ESTABLISHED BUSINESS of SUMMERS and SCOTT, LIMITED, GLOUCESTER

The PREMISES are Freehold, centrally situated, and have an area of over 7000 square yards.
The MODERN WORKS comprise Machine, Erecting and Fitting Shops, Smithy, &c. &c. Complete Equipment of Plant, Tools, Travelling Cranes, &c., valuable Patent, Patterns, and Drawings.
The FOUNDRY (Leasehold) can be included if desired.
Railway accommodation, and close to Ship Canal.
FULL PARTICULARS may be obtained from the Receiver, Mr. F. W. SMITH, Incorporated Accountant, New Inn-chambers, King-street, GLOUCESTER. 877

Conveyors and Elevators, Gear

Wheels, Sprocket Wheels, Chain, Belts, Shafting, Pedestals, Brackets, Fixings, and Castings.—Address, NEW CONVEYOR COY., Ltd., Engineers and Ironfounders, Smethwick, Birmingham. Y969

Electric Pump and Hoist Gears.

See Advertisement, last week, page 41.
GIMSON AND CO., LEICESTER, LIMITED,
VULCAN ROAD, LEICESTER. nx Y740

CEMENT MACHINERY.
Ernest Newell and Co., Ltd.,

MISTERTON, GAINSBORO, having an experienced and expert staff, are PREPARED to SUPPLY all NECESSARY MACHINERY, including Rotary Kilns; also to Advise upon Sites, Raw Materials, &c. nx421

John Spencer and Sons, Limited,

NEWBURN STEEL WORKS, NEWCASTLE-ON-TYNE.—Springs, Buffers, Steel Castings, Forgings, Tool Steel, Files, Tubular Piles, &c., Siemens Steel Blooms and Bars.
London Office: 32, Victoria-street, Westminster, S.W. J5

Johnson and Phillips, Limited,

ELECTRICAL AND TELEGRAPH ENGINEERS, CONTRACTORS, AND CABLE MAKERS.
Works: CHARLTON, Kent.
Makers of Machinery, &c., for complete equipment of Cable Factories and Vessels. Electric Light Apparatus of all kinds. Arc Lamps. Electric Transmission of Power Plant. G1521

Machine and Engineering Work

of all description UNDERTAKEN for Manufacturers, Patentees, &c; also REPAIRS and RENEWALS. Best work; moderate charges.—ROSSER and RUSSELL, Ltd., Queen's Wharf, Hammersmith. Spl nx422

Tank Locomotives, 4 or 6 Wheels

coupled. Specification and workmanship equal to main line engines.—Apply to R. and W. HAWTHORN, LESLIE and CO., Limited, Engineers, Newcastle-on-Tyne. (Spl) nx2
See Illustrated Advertisement this week, page 52.

W. S. Laycock, Ltd., Manufac-

TURERS of Steamship and Railway Carriage Specialities, Fittings, &c. &c., Government and Railway Contractors. Patent Automatic Coupler (M.C.B., type).—Victoria Works, Millhouses, Sheffield. Telegrams: "Invention Sheffield." Telephone: 907 and 958. (Spl) nx466

Wheatley Kirk, Price and Co.

LONDON, MANCHESTER, and NEWCASTLE-ON-TYNE.
(Established 1856.)
MECHANICAL AND ELECTRICAL
VALUERS,
ARBITRATORS, AND
AUCTIONEERS.
We also make a speciality of, and invite confidential communications in
ENGINEERING PARTNERSHIPS
from Firms of Good Repute and Practical Engineers with Capital.
London: 46, WATLING STREET, E.C.
Manchester: ALBERT CHAMBERS, ALBERT-SQUARE.
Newcastle-on-Tyne: 26, COLLINGWOOD STREET.

London	Manchester:	Newcast'e:	Spins.
5077 Bank.	3218 Central.	3229 Central.	'Phones.
"Indices.	"Indicator."	"Indicator."	Grams.

Prosperous Ironfoundry in

London for DISPOSAL as a GOING CONCERN, owing to illness of proprietor. Old-established connection, capital premises, lofty foundry 112ft. by 36ft., another 96ft. by 40ft.; three core drying stoves, three cupolas, brass foundry, offices. In excellent business district, ample yard space. Equipped with electric cranes, engine, boiler, grinding and sifting plant. Capacity 60 tons per week when busy. Freehold and Plant can be Purchased or rented at a low rental. An unusual opportunity to acquire an old-established business cheaply.—Apply to WHEATLEY KIRK, PRICE and CO., 46, Watling-street, London, E.C. 773

AIR COMPRESSORS, ROCK BORING MACHINERY.

SCHRAM, HARKER AND CO., (Spl.) nx171
CANNON-STREET HOUSE, LONDON, E.C.

BUCKTON TOOLS.

See Illustrated Advertisement last week, page 3d.

"CASE-HARDENING IS USELESS"

UNLESS YOU
USE THE RIGHT MATERIAL. Sp nx470
See Advt. of DURVITE LTD. in issue of Dec. 20.

CONVEYOR & ELEVATOR CO.

ACCRINGTON.
See Advertisement last week, PAGE XI. nx1117

CHEAP GAS FROM COMMON FUELS

FOR
Engines, Manufacturing, Furnaces, Pumping, Irrigation, Incandescent Lighting, and Generation of Electricity.
Lane's Producers are available for Land, River, or Ocean Service. Agents Required.
For Illustrated Descriptive Pamphlet, address— (Spl) nx452
HOWARD LANE, 25, Edmund-st., Birmingham, England.

CRANES.

HAND, STEAM, ELECTRIC.
LATEST DESIGNS. (Spl) nx465
BRAMLEY ENGINEERING CO., LIMITED, LEEDS.

STEEL AND IRON. **FORGINGS.** ROUGH OR FINISHED.
HOLLOW CRANK AND OTHER SHAFTS.
INCE FORGE CO., LTD., WIGAN. nx107

HARPER'S LIST.

PAGES XIV.—XV.
THREE WEEKS AGO

MINING TOOLS, ROCK BORING MACHINES, AND DRILL STEEL.

Large stocks. Prompt delivery
THE HARDY PATENT PICK CO., LTD.,
SHEFFIELD, ENGLAND. nx146

R. BOBY, LIMITED.

MANUFACTURERS OF:—
CORN SCREENS, AND MALTING APPLIANCES.
BURY ST. EDMUNDS.

STONE BREAKERS.

BAXTER'S PATENTS ARE THE BEST.
W. H. BAXTER, LTD. LEEDS. (Spl) nx155

TANKS,

CONSTRUCTIONAL IRONWORK AND GALVANIZING
JOSEPH ASH & SON,
nx164 Rea Street South, BIRMINGHAM.

TUBES & FITTINGS, IRON AND STEEL.

Tubes for Gas, Water, Steam and Compressed Air. Electric Tramway Poles, Pit Props, High-pressure Steam Mains, &c.
JOHN SPENCER LTD., GLOBE TUBE WORKS, WEDNESBURY.

VALUATIONS
Wood and Newland,

42, SPRING-GARDENS, MANCHESTER.
VALUERS and AUCTIONEERS to Engineering and Allied Trades. nx11
Partnerships and Transfer of Businesses negotiated.

Mr. John Price, M.I. Mech. E.,

INSPECTOR of RAILS. Railway rolling stock; iron and steel of every description. Postal and telegraphic address PRICE, Workington. Established 1876. Y773

CARTOONS AND DIAGRAMS
For Parliamentary Committees, Public Meetings, &c.
Robert J. Cook and Hammond

(Established in Westminster, 1860),
LITHOGRAPHERS Spnx467
2 and 3, TOTHILL-STREET, WESTMINSTER.
Tele. Add.: "Cartoons, London." Tele.: No. 551 Victoria.

Peter Hooker, Limited, Black-

HORSE-LANE, WALTHAMSTOW, LONDON, E.
ENGINEERS AND IRONFOUNDERS.
Will undertake the manufacture of SPECIAL MACHINERY also MACHINE WORK.
PLAIN GRINDING up to 10in. dia. by 84in. long.
RACK and GEAR CUTTING. R2

DRAWINGS, TRACINGS, MODELS OF BUILDINGS, &c.
PHOTO-COPIES (OR SUN PRINTS), LITHO. PRINTING.

THE LONDON DRAWING AND TRACING OFFICE, 96, Gray's Inn-road, W.C. (adjoining Holborn Town Hall).
Telephone—No. 1011 Holborn. Manager, John B. Thorp. Telegrams—Dividitors, London.

Printed for the Proprietors by Sydney White at the Office of Greeon Rivers, Greystoke-place, Fetter-lane, and published weekly by him at The Engineer Office, 33, Norfolk-street, Strand, in the Parish of St. Clement Danes, in the County of Middlesex.